POWER PLANT ENGINEERING

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Canadian Niagara Hydroelectric Power

WORK OF CANADIAN HYDRO-ELECTRIC POWER COMMISSION ON NIAGARA SYSTEM; EXTENSION IN ONTARIO POWER CO.'S. PLANT; QUEENSTON-CHIPPEWA POWER DEVELOPMENT. BY FRANK C. PERKINS

ON ACCOUNT of the power shortage caused by the extra energy needed for essential war industries and the fact that two of the plants at Niagara Falls had reached their capacity, work was commenced in March, 1918, for the extension to the hydro-electric plant of the Ontario Power Co., at Niagara Falls, Ontario, which, when completed, will furnish an additional 40,000 to 50,000 hp. 10.5-ft. diameter penstocks and two 20,000-hp. turbines with direct connected generators; also the erection of the additional power house to house these units.

It may be stated that the unique features about this extension are the wood stave pipe, which is one of the largest ever built, the differential surge tank, which has the largest diameter and has also the greatest height of any similar tank not equipped with an auxiliary spillway, and the power house walls, which were designed to

FIG. 1. ROCK EXCAVATION FOR HYDRAULIC WOOD STAVE PIPE

The construction of this extension involved the excavation of 133,000 yd. of earth and 14,000 yd. of rock to permit the placing of a 13.5-ft. diameter wood stave pipe 6700 ft. long, a 13.5-ft. diameter steel distributor 179.5 ft. long, a 60-ft. diameter steel differential surge tank 94 ft. high, four hydraulic operated valves, two withstand a pressure due to a 40-ft. rise in tailwater elevation, this extraordinary condition having occurred in the year 1909. The present plant of the Ontario Power Co. as now controlled and operated by the Hydro-Electric Power Commission, consists of an installation of 14 turbines, seven with a rated capacity of 11,800 hp.,

five rated at 15,000 hp., and two at 16,000 hp., making a total of 189,600 hp.

The generators, which are direct connected, have a total rating of 149,012 kv.a., and water is supplied through two 18-ft. diameter conduits, each approximately 6600 ft. long, having a combined maximum capacity of about 162,000 hp. The first conduit, of steel plate construction, was installed in 1903, while the second conduit, of reinforced concrete construction, was installed in 1910. The second conduit, when inspected in April, 1918, after being in service 8 yr., showed no signs of cavitation or deterioration, although a velocity of 25 to 28 ft. p. s. had been maintained during operation, nor was there any vegetable growth whatever appearing on the walls.

It will be of interest to note that the third conduit which is now being installed is 13.5 ft. inside diameter. The staves are of fir 4 in. thick by 6 in. wide and banded with ⅞-in. diameter steel bands, in two sections with two shoes. The pipe is carried on timber saddles spaced at 4½-ft. centers, except where the pipe is concreted in place. The excavation for trench for the wood stave pipe line was handled from the cut by shovels, derricks and locomotive cranes. The difficulties in this work were varied and in some places severe, due to the close proximity of the second conduit and to large quantities of water which were encountered at the upper end of the pipe line and at Dufferin Island crossing. A portion of the excavation was deposited along the sides of the cut for back-fill, while the remainder was placed on dumps located at convenient points.

It may be mentioned that the saddles used to support the pipes are built-up timber sections so constructed as to make a continuous form for the lower half of the pipe. Mud sills were used under the saddles through the earth cut, in order to distribute the load of the pipe and prevent settlement as far as possible. Through the rock cut, the mud sills were left out and the lower limits of the saddles were placed on the rock, which was evened up to grade after excavating the trench. On account of the bottom of the trench being below the water level in the Niagara River for the greater portion of its length, it was necessary to provide ample drainage for the pipe trench. The drainage system consisted of two vitrified tile drains, one on either side of the pipe trench, laid with open joints in broken stone. These two tile drains run from Station 9-00 on the conduit to the steel distributor, where they are connected to the penstock drains which carry the drainage water down through the power house to the lower river. For 1000 ft. at the upper end and 825 ft. at the lower end, the pipe is concreted in place. This was necessary in order to allow the pipe in these sections of the trench to be backfilled and thus restore the surface of the park to its original condition.

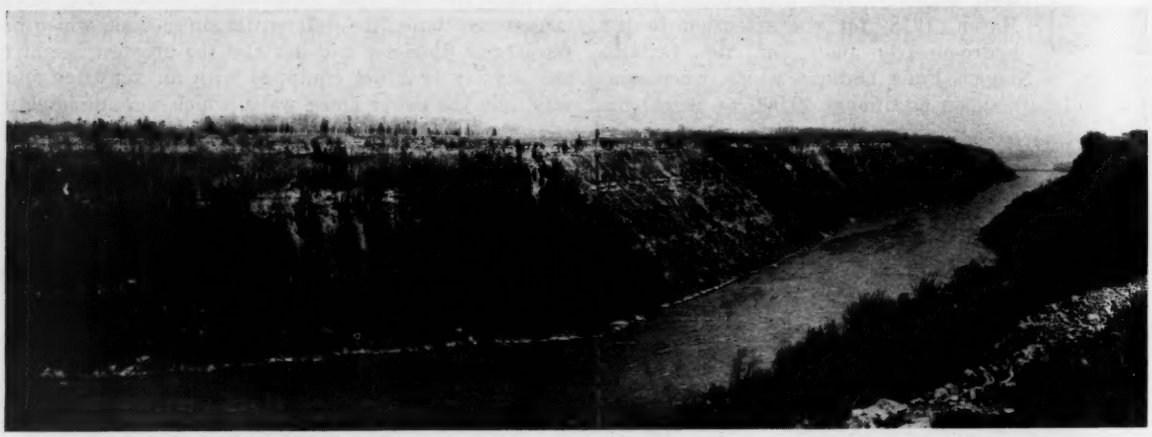


FIG. 2. PANORAMA VIEW OF POWER HOUSE SITE ON LOWER RIVER

Penstocks

The engineer of the Commission decided that the steel distributor at the lower end of the wood stave pipe should be made of ⅝-in. steel plate, 13.5 ft. in diameter and 179.5 ft. long. Four penstocks are connected to this distributor by means of bell-mouthed tees made of ½-in. steel plate. The distributor is incased in concrete so as to allow the surface of the park above it to be restored to its original condition. A section of 13.5-ft. diameter reinforced concrete pipe 77 ft. long connects the distributor with the surge tank. The surge tank is of the differential type. The tank is built of steel plate varying in thickness from ¼-in. plate at the top to 1-in. plate at the bottom, while the internal riser is built of ½-in. plate. The roof for the tank is constructed of steel roof trusses with wood covering.

In addition to the 14 penstocks now installed, two more are being installed to deliver the water to the two new turbines in the power house, which are 216 ft. in length. Each penstock ends in a supply pipe with taper connections bolted to the spiral casings of the turbine. The steel plate used in the construction of the penstock varies in thickness from ⅜ in. at the upper end to 13/16 in. at the lower end. The supply pipes are constructed of 13/16-in. plate throughout.

The engineers designed the penstocks for a pressure equal to 150 ft. head at the upper end, increasing to 320 ft. at the lower end, these figures including pressure rise due to a turbine gate closure time of 3 sec., with relief valve closed. The space between the excavation and the outside of the pipe is filled in with lean concrete, and this holds the penstock in position and protects the outside from corrosion. The water wheels are double runner, central discharge turbines with spiral casings, running at 187.5 r.p.m. and delivering 20,000

hp. under 180 ft. head. The turbine gates are operated by vertical servo-motors which are controlled by actuators mounted on the gallery. These actuators are equipped with distance speed controllers, hydraulic hand controllers, gate limiting device, manual speed adjuster, gate opening indicator and tachometer. The pressure oil for operating the servo-motors is furnished by helical gear rotary pump, delivering 62.5 gal. per minute against 200 lb. pressure. The sump tanks are each of 350 gal. capacity and are provided with screens for cleaning the oil before it is returned to the pressure tank.

Power House Construction

In the extension of the Ontario Power Plant, as well as the Queenston-Chippewa development, the power houses are of concrete and structural steel construction. In the substructure plain concrete has been used throughout, except for the concrete over the draft tubes, which has been reinforced for the upward pressure which will occur with high water in the river. The generator pits, air ducts and sump well are also reinforced to prevent injury developing from the temporary severe loading of portions of the structure during the erection of the units and from vibration when the plant is in operation. In the superstructure reinforced and plain concrete and structural steel are used. So as to protect the power house against a recurrence of the high water conditions which prevailed in 1909, the window sills in the front and end walls were placed at elevation 388 and the walls designed to withstand pressure due to water at this elevation on the outside power house.

Surge Tanks

The Commission's engineers point out that the hydraulics of the plant are of more than ordinary interest, due to the fact that the three pipe lines and surge tanks that have been installed differ considerably. For this reason an excellent opportunity is presented of making a comparison of their respective hydraulic characteristics and capacities. The first tank has very little capacity and is of the simple tank type. Its only function is to limit the surge pressure on the first conduit during load changes, and provides entrance to a spillway for discharge of water at times of load rejection.

It is claimed that the second surge tank, of the differential type, was the first tank of this character ever built. This tank serves the double purpose of relieving pressure surges and furnishing or storing water during load changes while the velocity in the second conduit is being accelerated or retarded. It is also equipped with a spillway as an additional safeguard, to prevent spilling over the top at times of abnormal surge, and to limit the height which would have been required without this provision.

The third surge tank is of the same type as the second, but has no spillway. Its design is such that full load rejection under the most abnormal conditions will not cause overflow. There were a series of tests made 6 yr. ago to determine the hydraulic characteristics and carrying capacities of the two conduits, also of the 14 penstocks. The results of these tests indicate some very striking facts regarding the relatively greater carrying capacity of concrete pipe as compared with riveted steel and also the exceedingly smooth surface that can be obtained with concrete, if proper and careful construction methods are used.

It is pointed out that the capacity of the third conduit, which is of wood stave construction, is 2750 cu. ft. per second, giving a velocity of 19.2 ft. per second in the pipe on the basis of a coefficient of roughness C = 135 in the Williams and Hazen formula. Under such conditions there will be a total loss in the conduit, from gate house to penstock, of 32 ft., which includes entry losses, friction loss and velocity head. This figure was arrived

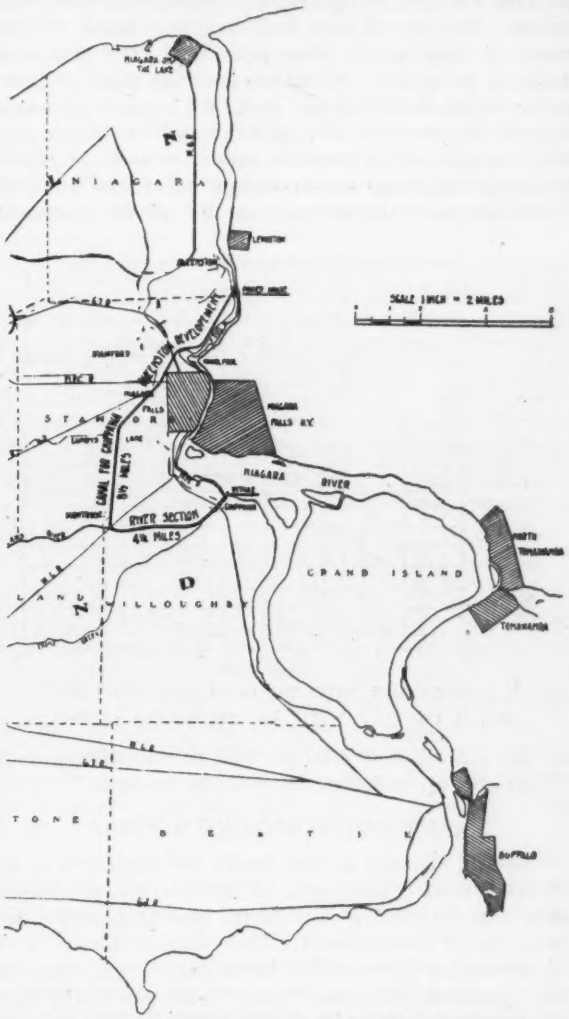


FIG. 3. MAP SHOWING CANAL ROUTE FOR CHIPPEWA-QUEENSTON DEVELOPMENT

at by assuming low-water elevation in forebay at 554, and the minimum elevation of the gradient at penstock No. 15 at 522, which is 8 ft. above the top of the conduit.

The engineers of the Commission state that from past experience with the first two conduits it was found advisable not to go below elevation 522 in order to prevent the gradient being drawn down below the top of the pipe under operating conditions. Under the above conditions the capacity of the pipe will be approximately 45,000 turbine hp. With a coefficient of roughness C = 150 in Williams and Hazen formula, which value is within the limits of possibility, and the same total loss

of 32 ft., the discharge capacity would be 2930 cu. ft. per second with a velocity of 20.5 ft. p. s. in the pipe. This quantity of water in turn would give approximately 48,000 turbine hp. In comparing the coefficients of roughness of the concrete and steel pipes, as obtained by test, and the assumed coefficient of roughness for the wood stave pipe, based on the tests published by the U. S. Department of Agriculture, it appears that the concrete pipe has the highest coefficient, with the wood stave pipe a good second, and the steel pipe a poor third. A coefficient of roughness of 100 in Williams and Hazen formula was used in figuring the losses in the steel penstocks. The use of this coefficient was based on the result of tests on the other penstocks. The tank was designed for a drop of full load on the third conduit, under which condition the tank will receive all water without the provision of a spillway and on the assumption that none of the pressure regulators on the turbines in the power house are in service. The conditions of design for load thrown on was that of an increment

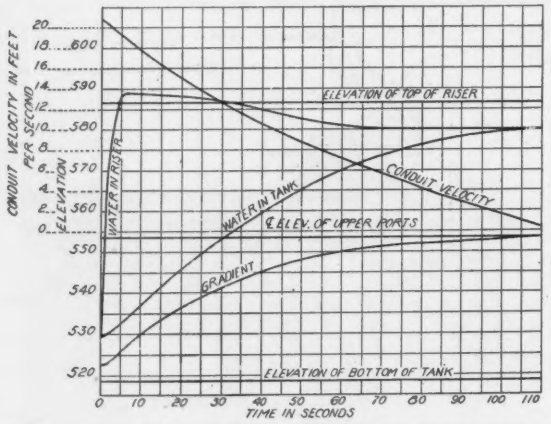


FIG. 4. SURGE TANK STUDIES; COMPLETE SHUT-DOWN ON NO. 3 CONDUIT WITH RELIEF VALVES CLOSED

of load equivalent to a 20 per cent velocity change from 80 per cent up to full capacity of the conduit.

Queenston-Chippewa Development

In the eleventh annual report the engineers of the Hydro-Electric Commission of the Province of Ontario give most interesting data of the new Queenston-Chippewa Power Development. They state that after 3 yr. of exhaustive surveys and investigation, the route for the Queenston-Chippewa Power Canal was finally fixed about 12¾ mi. long, with the intake on the Niagara River at Hog Island, Chippewa, about 2 mi. above Niagara Falls, and the tailrace on the Niagara River about 1 mi. above Queenston. The intake is in what is known as the Grass Island Pool of the Niagara River, and the mean monthly elevation of this pool varies about 1 ft. The normal mean elevation of Lake Erie is 573 ft.; of Grass Island Pool, 563; of the Niagara Power at the power house site, 247; and of Lake Ontario, 245. Probably no river has a more uniform regimen than the Niagara. The minimum flow is about half the maximum, and over a period of 50 yr. the maximum difference in mean monthly levels under normal conditions, either at Queenston or Chippewa, amounts to only about 6 ft.

It is said that the best intake and power house locations were first determined upon, with a view to the maximum utilization of the available head, and contours and borings were then studied to decide by what route a canal could connect those two points to the best hydraulic and economic advantage. The intake was located at Hog Island partly on account of that point being just above the critical section at which the water begins to speed up for its passage over the Falls. Location farther up the river would have meant a larger canal and farther downstream would have necessitated a loss of head. Another reason equally important for locating the intake at Chippewa was the use which could be made of the natural channel of the Welland River—often called Chippewa Creek—which comprises about 4¼ mi. of the route of the canal, leaving only about 8½ mi. to be excavated, although the Welland River will have to be somewhat deepened. The flow of the Welland River, which is a sluggish stream with a very flat gradient, will be reversed.

It will be seen how this 8½ mi. of excavated section compared with 19½ mi. for the old Jordan-Erie scheme; the net head is 305 ft., compared with a possible 299 ft. for the Jordan-Erie project. The ice troubles that would have been experienced with the latter project will be much more readily overcome with the new scheme. The gradients adopted for the canal average about 1 ft. a mile, or a total of about 8 ft. in the 8½ mi. of excavated canal. The loss of head in the penstocks, due to friction, may amount to upwards of 2½ ft., and the loss in the Welland River from Hog Island to Montrose, where the excavated canal begins, will be about 6 in. under maximum load, so that the total loss of head will be about 11 ft., making the net effective head about 305 ft. under normal conditions. Thus, of the 327 ft. normal difference in level between the two lakes, only 22 ft. head will be lost—10 ft. between Lake Erie and Hog Island and 11 ft. between the intake and the tailrace, and 2 ft. between the point of discharge of the tailwater and Lake Ontario.

It will be noted that the power house is located in the bottom of the gorge, about ¾ mi. above the Lewiston Bridge, just below where the last rough water disappears. The cliffs are nearly vertical at this point, and as the gatehouse is on the cliff immediately above the power house, the penstocks are nearly vertical and only about 450 ft. long, thus reducing cost and head loss to a minimum. With this scheme of development about 30 hp. are obtained from each second-foot of water used, compared with about 14 hp. per second-foot obtained by the existing plants at Niagara Falls. With 36,000 the whole Treaty allotment of second-feet available over 1,000,000 hp. could be similarly developed, as compared with less than half that amount at the heads under which the present plants at Niagara Falls are operating.

It may be stated that all of the excavated section of the canal is in solid rock, with the exception of 1¼ mi. of earth section running north from the Welland River and ½ mi. of earth section across the whirlpool ravine. These sections are trapezoidal in shape, lined with riprap, and the section at the whirlpool is to be faced with concrete. The rock section is 48 ft. wide at the bottom, with perpendicular sides, the average wetted section being 35 ft. deep and lined with concrete. The velocity

in the rock section will be about 6 ft. per second when the plant is under maximum load. The earth overburden above the rock surface will be generally sloped 1½ to 1, but a flatter slope is provided for where local conditions require it.

It may be mentioned that the Commission has purchased a tract of land as a right-of-way which will be sufficient for all present and future needs. This right-of-way includes about 200 acres near St. David's which will be used as a dump for the disposal of excavated earth and rock. There will be control works at the head of the excavated canal near Montrose, but from there the canal will be unobstructed until the forebay location is reached, which is at Smeaton's Ravine. At a point 2400 ft. distant from the gatehouse, the canal widens into the forebay, the forebay gradually increasing in width to 400 ft., which will be the approximate overall length of the gatehouse. The initial development provides for four steel penstocks each about 14 ft. in diameter, 450 ft. long, and one exciter penstock, about 5 ft. diameter.

The Canadian engineers have provided for the installation of four main generating units each of 50,000 hp. capacity. Both the gatehouse and the power house are so designed that they may be extended whenever conditions warrant, and practically to any desired extent. The turbines will be of the single runner type, probably with cast steel scroll cases. The specifications call for 187½ r.p.m., which is the maximum safe speed giving satisfactory hydraulic characteristics. The specifications for the turbines have been prepared by the Commission and prices will be secured in the near future. Although these turbines will have the greatest capacity of any water turbines yet designed, they will not be so large in overall dimensions as some others that have been built to operate at lower heads.

As in former practice in Canada, the power will be taken off the generators at 12,000 v. and will be stepped up, probably to 110,000 v., for long distance transmission. Elaborate arrangements will be made not only for leading cool air to the generators, but, what is more unusual, for taking the heated air out of the power house. Large ducts will lead cold air to below the rotors, and after the air has gone through the generators, it will be carried away in flues. There is also a scheme for removing the runners from the turbines without dismantling the turbines and generators, which will weigh about 1000 tons, the moving parts weighing about 500 tons. Each draft tube will be so arranged that the runner can be dropped into the draft tube, loaded into a car, pulled through a tunnel and lifted through a shaft by a crane, so that repairs can be effected without dismantling the unit. The power house will be served by two 150-ton electric cranes.

The work is now rapidly being pushed forward and it is of interest to note that the main equipment for the earth and rock excavation consists of the two largest electrically driven shovels ever built. Each shovel weighs over 300 tons, contains 75 tons of ballast, and has a capacity of 3000 to 5000 cu. yd. per 10-hr. day when handling earth.

The first substation is located at the Whirlpool, and the power comes into the station from the Ontario Power Company's plant at 12,000 v. and is stepped down to 4000 v. by transformers each of 1500-kv.a. capacity. The power is distributed up and down the canal at 4000 v. Other transformers step some of the power down from 4000 to 440 v. for use by the shovels. Three rotary converters, each of 500 kw., supply direct current at 600 v. for railway operation. At this substation there are now erected four belt-driven air compressors, each of 1000 cu. ft. per minute capacity against 125 lb. pressure. They are belt-driven from 200-hp. 550-v. motors, at 750 r.p.m. As the work progresses, additional compressors will be installed in this station. All of the rock drills, channellers and forges, and much of the other equipment, will be driven by compressed air. The air is piped up and down the canal for 3 mi. in each direction, the mains leading from the substation being 10 in. in diameter, reducing to 8 in. and 6 in. During the coming summer another substation will be built near Montrose which will be similarly equipped.

It may be stated that in the Whirlpool yards is located a large repair shop containing drills, shapers, planers, lathes, forges, steam-hammers and woodworking machines.

In this power development there are four railway bridges to be constructed over the canal—one for the Niagara, St. Catharines and Toronto Railway (electric), one for the Wabash Railroad, one for the Michigan Central Railroad, and one for the Grand Trunk and Michigan Central railroads. These will be reinforced concrete arch bridges. There will also have to be constructed a number of highways and foot bridges to carry the various roads across the canal. In the concrete work to date both Canada and St. Mary's cement have been used.

Ontario Power Extension

The Ontario power extension to generating equipment is of interest. The extension comprises an addition to the company's generating station building in the Niagara Gorge and the installation therein of two 15,000-kv.a. generators, together with the necessary excitation and switching equipment. Generator cables from the generating station to the company's distributing station on the top of the cliff and the necessary bus structures, switching and control equipment in the distribution station, are also to be provided.

It is stated that no extension to the distributing station building is required, but in the northwest corner the present switch room floor is extended to carry the new oil circuit breakers and additional switch and bus structures built; also a gallery floor for the installation of bus reactors. In the generating station two 15,000-kv.a., 75 per cent power factor, maximum rated, 3-phase, 25-cycle, 187.5-r.p.m. horizontal shaft, water wheel type generators are added.

It is of interest to note that in operation each generator will require 60,000 cu. ft. per minute of air to be forced through the ventilating ducts in its armature to enable the machine to carry its rated load with the specified temperature rise. The problem of supplying this ventilation was thoroughly studied by the engineers of the Commission and the scheme adopted involves (a) the enclosure of the sides of the generator armature and rotor above the floor line and the top of the generator pit around the machine, with a sheet steel housing, (b) the installation of a pair of motor driven blowers for each generator to deliver the required volume of

air into the generator pit at, or slightly above, atmospheric pressure, and (c) the use of fan blades on the generator rotor to force the air from the pit through the ventilating ducts in the machine. The cooling air from the outside atmosphere is brought into the power house through ducts formed in the solid concrete of the front wall of the building. These ducts, which have their outside opening high up in the front wall, to be above any recorded high water level, extend downward and discharge the air into a common air chamber located under the railroad track runway of the extension. The air is drawn through the ducts into this chamber by the blower units and is discharged directly into the generator pits, the blowers being located between the air chamber and the pits.

The heated air from the generators is discharged into the power house and a ventilating monitor 22 by 4½ ft. in size is provided in the roof directly over each generator. Four blower units, each capable of delivering 60,000 cu. ft. per minute of air, are driven by a direct connected 35-hp., 2200-v., 3-phase induction motors. One blower unit is used on each generator for normal operation, the other blower acting as a standby, and a duplicate system of power supply is provided for the blower motors. A temperature indicating outfit is being provided to indicate the hottest part of each generator winding.

Three 125-kw., 250-v. exciters are provided direct-driven by 185-hp., 2200-v., 3-phase induction motors. A 200-hp. starting auto-transformer and the necessary switching equipment and Tirrill regulators for two exciter units are utilized, and the third exciter set will be used as a spare unit in order to effect immediate replacement in case of a breakdown in one of the two units in operation. This safeguard is necessary, since in the system of excitation in use the leads from each exciter armature run direct to a main generator field.

There is a small auxiliary pit provided in the station substructure on either side of each main generator pit. The star point leads of each generator are brought outside of the generator frame and carried in porcelain bushings through the side wall of the generator pit into one of the auxiliary pits, where the star point of the machine is made through current transformers. The main leads of each generator are similarly carried into the other auxiliary pit and connected to a pothead bus. From the pothead pit three 3-conductor cables in parallel are carried through tile ducts in the station floor and up to a similar pothead bus under each generator switch recess in the back wall of the station.

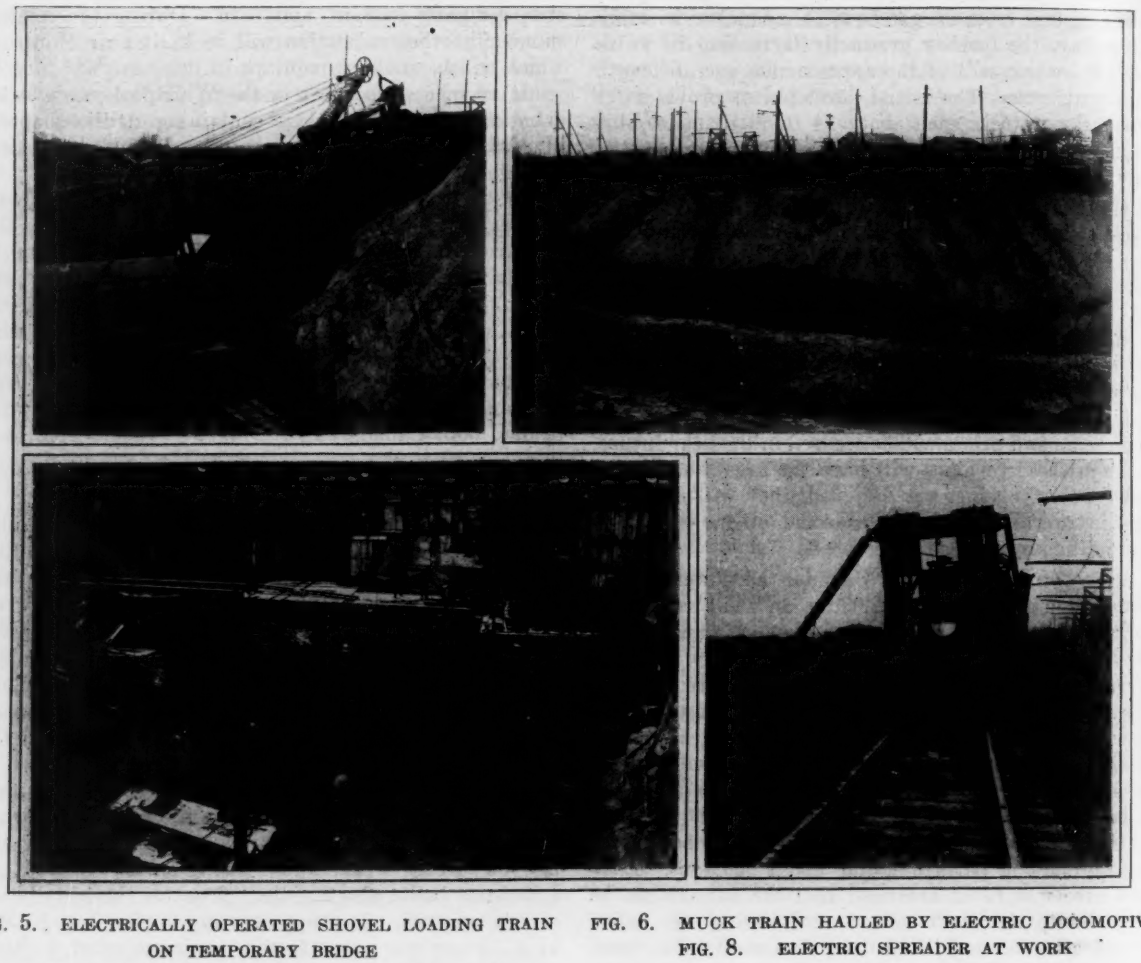


FIG. 5. ELECTRICALLY OPERATED SHOVEL LOADING TRAIN ON TEMPORARY BRIDGE

FIG. 6. MUCK TRAIN HAULED BY ELECTRIC LOCOMOTIVE

FIG. 7. EXCAVATION WORK AT POWER PLANT SITE

FIG. 8. ELECTRIC SPREADER AT WORK

In the switch recess a 1200-amp., 12,000-v. oil circuit breaker is utilized and from a second pothead bus at each switch recess, four 3-conductor cables in parallel are carried in tile ducts in the back wall, along the power house, and up through the existing cable tunnel to the distributing station on the top of the cliff. An extra heavy type of 3-conductor pothead is used on all of the 12,000-v. cables. All of the three conductor cables referred to are 350,000-c.m., 12,000-v., paper-insulated lead and armor covered.

At the distributing station an extension is being made of the present 12,000-v. busses in new bus structures, with provision for the installation of power limiting reactors between the new and the old sections. An extensive study of short-circuit currents has been made with the object of making the new construction as rugged as will be necessary. The extension of the busses will accommodate the two new generators and two new large capacity outgoing feeders to the Niagara transformer station of the Commission.

The writer is indebted to the engineers of the Commission for the data given in this article.

Some Notes on Economizers

By Mark Meredith

A NOT INFREQUENT trouble with economizers is leakage from the top branch pipe joints. The theory is sometimes put forward that this is caused by the seating upon which the bottom boxes rest being in bad condition. It is doubtful, however, if this assumption is correct. If the support is partially or wholly removed from one or more sections an increased stress will be thrown upon the bolts and necks of the flanges, but it does not appear sufficient to affect the solidarity of the joints. What is advanced as a more probable cause of the trouble is the sudden change of temperature occasioned when the apparatus is worked in an improper manner.

When standing, with boiler fires banked, or at any other time when water is not being circulated through the economizer, if the flue gases are sent through the economizer chamber the water in the pipes may attain a high temperature. Upon starting up, the engine or "make-up" water being pumped into the boiler during the night, the temperature will probably fall 200 deg. or more in the space of a few minutes, with consequent contraction of the metal. Under such conditions, rapid deterioration of the jointing material may be looked for. A bypass damper is generally fitted, and probably this would, in the majority of cases, prevent all trouble with the joints. Unfortunately, it frequently happens that the bypass damper is used only at times when the economizer is going to be put out of commission.

Neglect of the bypass damper under the conditions stated is also bad practice in another way. Steam may be found in the economizer, and water hammer occasioned upon starting up. Several cases of burst feed pipes have been due to this cause. One of the first cares of the attendant should, therefore, be to watch the thermometer carefully, and prevent all sudden fluctuations in the temperature.

The fact that dangerous, and even fatal explosions can occur with economizers is frequently overlooked, some engineers waiting until pipes begin to burst before considering the question of renewal. Generally, it is admitted, a burst pipe, though inconvenient, is not serious, but such is not always the case.

Bursting of an economizer pipe is due generally either to deposit on the inside of the pipe, or to the thickness of the metal being reduced by wasting, until it is insufficient to withstand the working pressure. With excessive and hard scale, the pipes usually fail when the apparatus is cooling down preparatory to cleaning, and is not under pressure. It is caused by the natural contraction of the metal being prevented by the coating of scale, and the pipe fractures as a result.

The two most common forms of wasting are smooth wasting at the bottom ends of the pipe externally, due to the temperature off the entering feed being too low; and graphite wasting internally. The former is generally more severe on those pipes adjacent to the bottom branch pipe. Thus the first pipe in a row of eight may be 4 in. diameter, while the last pipe has, perhaps, only wasted to 4 in. diameter. The "first" pipes, where no small inspection doors were fitted in the wall, can be calipered only at the end of a nest. Where this is the case, and the wasting on other pipes is considerable, it is advisable to cut holes in the front wall to enable the extent of the wasting upon the "first" pipes to be ascertained; 4½ in. is generally considered the least diameter allowable consistent with safety. Upon reaching this, the row in which the pipe is situated should be blanked off, or the pipe renewed.

Graphite wasting occurs internally, and is more difficult to detect. It is caused by the action of the water upon the metal, which in the course of years is transformed into a graphite-like mass, the original size and shape being retained. It usually commences in the pipes at the cold end, and although it occurs more rapidly with some waters than others, it does not, as a rule, attain serious proportions until the apparatus has been in use for at least 12 yr.

Perhaps the best way to detect this form of wasting is to knock in a cap at the cold end, and with a flat chisel tap the end of the pipe where it projects through the top box. The degree of softness can thus be readily determined. If the wasting is found to be extensive, two or three pipes should be cut out and broken up. This may appear rather drastic, but it is the only method by which the condition of the pipes can be definitely ascertained. Should the wasting be severe, the pipe will be found appreciably lighter than one in which the metal is sound. When broken up, an examination of the fracture shows clearly the extent of the wasting, the sound metal being considerably lighter in color than that which has deteriorated.

"I GUESS I'm far enough down the row," mused the station mechanic, as he paused in his walk down the long switch alley before the compartment of a 13,200-v. disconnecting switch, and without further ado, removed the compartment door and went to work with a wrench on a bare copper lug. Sixty seconds later, there was only a heap of debris left of lug, wrench and mechanic.

TO STAND still is to stagnate. Methods change. This year's goal kick may be next year's fumble.

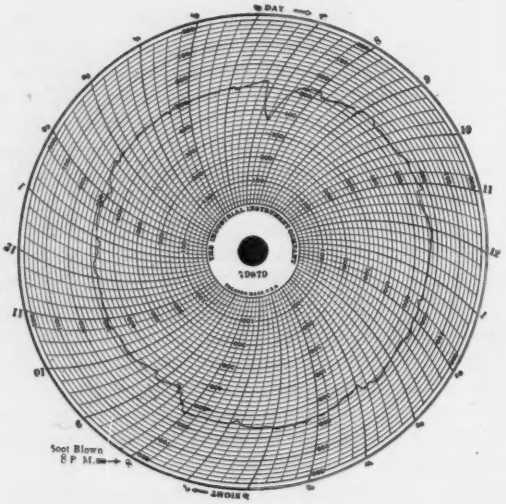
FUEL CONSERVATION LETTERS

By Joseph Harrington, Formerly Administrative Engineer for the State of Illinois

Flue Temperature. Letter No. 20

ONE OF the largest losses occurring in the boiler room is the heat which passes up the stack with the flue gases. Even with well-designed and operated boilers, the loss up the chimney amounts to 10 per cent; and in poorer settings, which undoubtedly represent more nearly the average setting, the loss may be as high as 30 per cent. The temperature of these gases is not, of course, the complete index of the loss. It is necessary to keep down the volume of gas as well as the temperature if the loss is to be avoided.

Soot accumulates on the tubes constantly and makes its presence felt within a few hours of the soot-blowing period. A recording thermometer will show the effect of blowing soot in the clearest manner. After the tubes have been cleaned the temperature will drop a very appreciable amount—frequently as much as 50 degrees. The temperature will then gradually rise until at the end of eight to twelve hours it will have regained its former degree. The extent and rapidity of this increase is, of course, largely dependent, if not entirely so, upon the furnace conditions; it being much more rapid with smoky furnaces and the incomplete combustion consequent upon irregular hand-firing or excessive rates of combustion.



Soot is about as good an insulator as we could well find, and it is absolutely vital that it be kept off of the tubes. The temperature of the flue gases therefore becomes a direct index of the condition of the boiler-heating surface.

Another valuable feature of this indication is in showing the operator whether or not the baffles are as they should be, by checking the draft loss indications. If a low draft loss is combined with a high flue temperature, attention should at once be given to the tightness of the baffles, a hole producing just the two effects above mentioned.

There is, approximately speaking, a loss in efficiency of 1 per cent for every 25 degrees rise in flue temperature. Very definite information can therefore be obtained as to the possibilities of saving by knowing what the flue temperature is and what it would be under proper conditions of construction and operation. Upon this question of flue temperature hinges the entire problem of feed-water economizers. It is not practical to reduce the flue temperature below a certain definite point. If this is done, there is a condensation of moisture which usually carries with it a corrosive acid, injurious to exposed metal and producing a sticky soot which it is almost impossible to remove. About 400 degrees is the minimum limit with an economizer, so that you can easily figure what you could save by such an installation. Remember, however, that the rate of heat transfer varies directly as the difference in temperature between the hot gases and the object being heated. A greater "heat head" is therefore obtainable if the furnace gases pass over a cold feed-water-heated surface during their last stages, rather than a steam-heated surface.

You will find that a study of your flue temperature is most interesting when taken in conjunction with the draft losses and gas analyses, soot-blowing periods and the general internal cleanliness of the boiler. A scale deposit inside the tubes also has an insulating effect and should properly be included in the causes affecting flue temperature.

Inasmuch as the stack loss is one of the heaviest suffered in the boiler room, nothing bearing on it can be considered superfluous. At least one recording instrument should be in each plant, and every boiler or breeching should be provided with the necessary hole for inserting the bulb. In your analyses of operating conditions the instrument can be kept in commission long enough to make your diagnosis, establish correct operation and can then be moved to another boiler.

Lubrication and Lubricating Oils

LAWS OF FRICTION; PRACTICAL TESTS FOR OILS; CHARACTER OF OILS FOR DIFFERENT PURPOSES. BY R. C. DEMARY

ON taking up the problem of lubrication, it is first necessary to study some of the laws of friction. There are five of these laws with which the engineer has to deal.

First—Friction will vary in proportion to the pressure on the surfaces; that is, if the pressure increases, the friction will increase, and vice versa.

Second—Friction is independent of the areas of the surfaces in contact, but if the pressure or friction be distributed over a larger area, the liability of heating becomes less.

Third—Friction increases with the roughness of the surfaces and becomes less as the surfaces become smoother.

Fourth—Friction is greatest at the beginning of motion.

Fifth—Friction is greater between soft bodies than hard bodies.

The foregoing laws, while generally accepted, are not altogether rigid, as has been proven by many eminent engineers. Friction is always a resisting and retarding factor and its tendency is to bring everything to a state of rest. With machinery in motion, the friction between the surfaces of the parts moving in contact tends to cause them to adhere to each other.

In order to operate the machinery successfully and economically, it is absolutely necessary that a lubricant be used that will distribute itself over these surfaces and prevent them from coming into direct contact.

Take a block of iron weighing 50 lb. and having a flat surface on one side and four legs on the other, each one having an area of 1 sq. in. To this block attach a cord and pass it over a small roller at one end of a table. Fasten weights to this cord until the block moves. It will be found that the same weight is required to move the block, whether on its four legs or on its flat surface. This illustrates the second law of friction and proves that the extent of surface in contact does not affect the friction so long as the weight or pressure remain constant; but, by allowing the large area to come in contact with the table surface, the pressure is distributed over a larger area and the liability of heating becomes much less.

In machine design, the object should be to obtain as large a bearing surface as possible, that the pressure per square inch may be reduced. Modern construction and methods of lubrication have reached such a degree of mechanical refinement that friction losses have been reduced to 3 per cent and in many cases less.

Lubrication is a problem that the average engineer knows little about because of the fact that there is little literature on the subject written in a practical form. Invariably it is too theoretical or is written in the interest of a certain brand of oils and the actual facts distorted to fit that particular brand.

TESTS FOR LUBRICANTS

A BRIEF description of a desirable lubricant is that it should be the least viscous and should stay in place.

Summarizing the commonly desirable characteristics, they are:

First—The oil should possess cohesion;

Second—It should possess the maximum possible adhesion;

Third—It should be as far as possible unchangeable;

Fourth—It should be commercially free from acid;

Fifth—It should be pure; that is, it should be what it purports to be.

The first test we will discuss is the viscosity test, which is used to measure the internal friction of the oil, or, as the engineer might say, the shearing modulus of the oil. This test is of value because a lubricant is really used to keep a shaft or journal and its bearings apart. The journal really revolves on a sheet of lubricant, an action which has been described as revolving on the molecules of the lubricant. The ease with which the molecules of the lubricant slide over one another therefore determines, to a certain extent, the friction loss in the bearing.

A very fine example of the effect of the viscosity of lubricating oil is furnished by the experience of a certain spinning mill. This mill was operated with power derived from a Corliss engine which was carrying its maximum load at all times. The lubricant used on the mill spindles was changed to one of a supposed better grade. It was then found that the engine did not have enough power to drive the spindles; in fact, it was unable to start the machinery in motion. Examination showed that the only difference between the two lubricants was the possession of higher viscosity by the new material.

The measurement of viscosity of lubricating oils is to a certain extent unsatisfactory because the results obtained with the different instruments which are available for making this test do not agree among themselves. It is therefore customary to state the instrument which was used in determining the viscosity.

One of the most commonly used viscosimeters is the so-called Sayboldt instrument. This is a pipette type, having a tall and rather small diameter pipette immersed in a jacket which may be used for maintaining any desirable temperature during the test. The test is made by filling the pipette to a certain point and noting the time of efflux. The time of efflux is then spoken of as the measure of the viscosity of the oil tested; or the so-called specific viscosity may be determined by dividing the time required for the efflux of the oil by the time required for the efflux of the corresponding volume of water. The Sayboldt instrument has been used by some manufacturers as a standard for many years.

The instrument now coming into general use in this country is known as the Engler viscosimeter. This differs from the Sayboldt principally in using a pipette of a larger diameter and not so long. It is used in the same way as the Sayboldt, but the specific viscosities as determined by the two instruments do not agree.

There is really no satisfactory test for the adhesive quality of a lubricant. It is commonly supposed to be

determined by a friction test. This test is made by measuring the frictional resistance offered to the rotation of a standard journal in a standard bearing when lubricated with the oil in question. The results obtained with this test depend partly upon the viscosity of the lubricant and partly upon its adhesiveness. Modern research shows that viscosity tests show about as much as do friction tests, but this is not necessarily so and must not be assumed to be universally applicable.

A third test, and one which is of great importance, is known as the gumming test. This is particularly applicable to petroleum oils and is used to indicate the extent to which the oil has been refined. It serves indirectly to indicate the extent to which the oil may be expected to change due to oxidation, when in use. Numerous opportunities have been offered to check the results obtained with this test and the results obtained in practice with the same oils, and all of this experience tends to show the great value of the gumming test.

This test is made by putting a small quantity of the oil to be tested in a small glass vessel, and then pouring upon it an equal quantity of nitrosulphuric acid. A properly refined oil will show little if any change but a poorly refined oil will be indicated by the separation of large quantities of material of a dark color. This color is due to the oxidation of the tarry matter contained in the lubricant. Experience has shown that oils containing a large percentage of tar absorb the most oxygen; that is, they are a drying oil. The results obtained by the gumming test agree very well with the carbon residue tests made by distilling to dryness in a glass or fused quartz flask. The carbon residue test has been found of great assistance in choosing a satisfactory cylinder lubricant for gas and oil engines, as a large amount of carbon means trouble in the gas or oil engine cylinders. The lowest carbon content I have determined was slightly under 0.12 per cent. The oil giving this test showed no tar when tested with nitrosulphuric acid. In general, a gas engine oil should not contain more than 0.4 per cent carbon as determined by the carbon residue test.

When an oil has been found to have satisfactory viscosity and has given satisfactory results in a gumming test, it should next be checked for safety; that is, the fire and flash test must be made. The amount of volatile matter given off at the temperature at which the lubricant is to be used is very often of great importance. A case is on record in which a serious fire was spread by the vapors given off by the oil used on the various bearings. The oil used in the mill was found on testing to give off 30 per cent of volatile matter when the temperature was raised to 140 deg. F.

It is advisable to include an evaporation test with the flash test of a lubricant. The evaporation test is made by exposing about 0.3 of a gram of oil at a certain temperature and noting the loss in weight in a given time.

The flash test is made by heating the oil slowly in a vessel surrounded by a proper bath and determining the lowest temperature at which a flame will ignite the vapors which are given off.

It is also necessary that lubricating oils should be practically free from acid, and the so-called acid test is made to determine the extent of the acid content. Mineral oils are agitated with sulphuric acid during the refining process for the purpose of removing the tarry materials, and this acid must be entirely removed from the oil before it is placed on the market. Oils may become contaminated with acid from another source as well; namely, the animal or vegetable oils with which they are sometimes mixed for the purpose of modifying their characteristics. A content of about 0.2 per cent is considered the maximum allowed.

It is sometimes desirable to determine the character of the raw material from which a given lubricating oil is made. This can be done in case of oils refined from petroleum by means of the specific gravity test. Lubricants made from petroleum with an asphalt base are from 7 to 10 deg. Baume heavier than lubricants made from petroleum having a paraffin base.

In examining oils, it is well to bear in mind that the viscosity is easily increased by the use of a material known as oil pulp or oil thickener. This is really oleate of alumina, and while it brings up the viscosity, it does not give the lubricating results expected when that particular viscosity was specified. At ordinary temperatures a small quantity of this material will enormously raise the viscosity.

There is another test known as the cold test which is of value in certain cases. If an oil is to lubricate a bearing, it must be fluid enough at the temperature of use to flow readily into that bearing. Many bearings have been ruined through the use of an oil which became too viscous to flow under the conditions as used. For such reasons, it is customary to chill a sample of the oil to determine at what temperature it becomes too thick to flow readily.

Tests other than those described are often made on animal and vegetable oils. They are used to determine whether the oil under test is what it is supposed to be. It is a simple matter to mix different animal and vegetable oils in such a way that they will give a product capable of passing any one or possibly two of the tests given, but it is impossible to make such a mixture pass all the tests which would be passed by the pure oil for which the mixture is to serve as substitute.

The engineer is at a disadvantage in testing such mixtures, because there are no exact specific tests for some of the animal and vegetable oils. The presence of some can be determined absolutely, but unfortunately this is not true of all.

The iodine test, by which is meant the determination of the percentage of iodine absorbed by the oil under set conditions, has long been used to indicate the character of the vegetable and animal oils present in a sample. At one time it was believed that the so-called iodine number was a constant for any one oil and that this test was perfect. It is known now that this is not true, the iodine number varying with the condition of the material from which the oil was made.

It is a very simple matter to determine the presence of petroleum oils in a mixture of animal and vegetable oils. This is done by saponification, which serves to separate the petroleum oil, which does not saponify, from the others which do.

There is a comparatively new test, known as the Maumene test, which gives results comparable with those obtained with the iodine test, but is much simpler and therefore more readily performed by the average indi-

vidual. For this test, 50 grams of oil and 10 c.c. of sulphuric acid are placed in a beaker and slowly heated. The maximum temperature rise which occurs during the subsequent distillation is noted and used as an indication of the character of the oil.

Oils for Different Purposes

It should be appreciated by the practical man that all of the tests of lubricating oils give only approximate results. Thus any one viscosimeter will give consistent results on the same material at the same temperature, but different instruments of the same type will give results on the same material which will vary several per cent. Large errors are often obtained when using friction machines. With tests otherwise properly conducted, it appears that the absorption of oil by the journals and bearings may be sufficient to cause very appreciable errors.

A bearing running at a high temperature has a tendency to lower the viscosity of the oil and thus decrease the friction set up by the molecules. Cooling the bearing increases the friction, thus proving that there is nothing gained by running it at too low a temperature; in fact, the bearing should be run at as high a temperature as possible, just so long as it is getting good clean oil and lots of it and the surfaces are in good condition. The writer recently had his attention called to a turbine where the bearings run regularly at a temperature of 210 deg. F. and have never given the least trouble. Cooling a bearing below a fair working temperature by flooding it with oil, results in a waste of power as well as a waste of lubricant.

Increasing the load on a bearing does not necessaril increase the friction, but it has a tendency to squeeze out the oil film from between the surfaces and thus destroy the lubricating effects of the oil. It is important to use an oil with body enough to prevent it from being squeezed out with the maximum load. This will mean the use of an oil with a higher viscosity, but the engineer must not lose sight of the fact that the friction will also be increased and the bearing will have a much higher temperature.

On modern high-speed engines, the best results will be obtained from a light oil. The bearings on this type of engine are generally designed so that the pressure is not great per square inch and there is little danger of the oil being squeezed out. For turbine bearings, the best results are always obtained with an oil of very low viscosity.

An oil having a low viscosity should also be used on the bearings of motors and generators, as they are so designed and in nearly every case equipped with ring oilers.

The writer is in charge of a power plant where one of the units is a 250-hp. slide valve engine, direct connected to a generator and having a speed of 250 r.p.m.

Considerable trouble was experienced in keeping the main bearings at a temperature below the danger point. A very light turbine oil having a viscosity of 140 at 100 deg. F. was tried (but against the advice of several leading oil men and engineers) and found to give excellent results, the temperature of the bearings at no time nearing the danger point.

In lubricating the valves and cylinders of steam engines, conditions are entirely different. Bearings and journals can have the lubricant applied direct, while in the other case the flow of steam is depended upon to carry the oil to the parts to be lubricated. Here we must take into consideration the nature of the steam, its pressure, piston speed, weight and fit of the moving parts. Where the steam is wet, the lubricant is liable to be washed off. To prevent this, a compounded oil should be used; that is, a mineral oil having a small percentage of lard oil, tallow, or rape seed oil should be added. This mixture will emulsify and have a tendency to adhere to the surfaces to be lubricated. The objection to tallow is that the stearic acid will be liberated, causing increased corrosion and scale.

Where the steam is very wet little or no cylinder oil is required. In marine engines of the reciprocating type practically no oil is used in the cylinders after the first few weeks' running. The wet steam furnishes all the lubrication necessary.

Where superheated steam is used, a straight mineral oil will give the best results. It should also have a higher flash point.

In compound engines, it is often necessary to use a straight mineral oil in the high-pressure cylinder and a compounded oil in the low-pressure side, the latter cylinder always receiving steam containing more or less moisture.

In regard to the lubrication of air compressor cylinders, there seems to be a great diversity of opinion. Many engineers advocate the use of cylinder oil, as used in steam cylinders while others use various grades of compounded oils, nearly all of which have a high viscosity and a high flash point. Manufacturers of lubricating oils as well as salesmen always recommend oils of the latter kind because, they will tell you, of the high temperatures of the cylinder walls. Theoretically this is so, but in practice we find a different situation. Where the water jackets are kept clean and free from scale and mud, the cylinder walls will not reach a temperature of more than 30 deg. F. above the temperature of the jacket water, just so long as it is kept below the boiling point. Inasmuch as this is true, why should we use a lubricant with a high viscosity and a high flash point? In fact, oils of this nature tend to gum and cause fouling of the valves and also leave deposits of carbon. There is also danger of carrying vapors into the receivers with resultant explosions. For single and two-stage compressors where the air is compressed to not more than 150 lb. per square inch, a light oil having a viscosity of about 150 to 160 at 100 deg. F. will be the most satisfactory.

In nearly all of the large compressor plants in the copper mining district of Northern Michigan, a very light engine or turbine oil is used, and for cylinders 24 by 14 by 20 in. not more than three and in most cases only two drops of oil per minute are used. The air cylinders are always well lubricated.

The Eastern oils or those of Pennsylvania and Ohio have a paraffin base and are considered by some engineers to be superior to those of the Western states which have an asphalt base. In actual tests, however, the Western oils frequently show a slightly higher lubricating value and less carbon than the Eastern oils. In lubricating the cylinders of large gas and oil engines

and those of the Diesel type, the Western oils or those having an asphalt base are found to give far better results than the oils having a paraffin base.

In selecting oils for lubrication, the engineer must not lose sight of the fact that there are many conditions about a power plant that will have an effect on the lubricating value of the oil. Where the continuous oiling systems are used, more or less water will find its way into the oil from the piston rod condensation. An oil must be chosen which will not emulsify, will separate quickly and will stand up under these peculiar conditions. Where the steam is wet and certain boiler compounds are used, another factor must be considered. The compound carried over in the wet steam and mixing with the oil may cause it to lose its lubricating value. On the same type of engine and under the same conditions, except with the boiler compound omitted or where another kind is used the same oil may give excellent results.

No rigid directions can be given for the choice of oils for a given purpose. It is best to try various lubricants which can be purchased for any given lubricating problem until one is found which gives satisfactory results. This should then be thoroughly tested and the results of the test used in writing specifications on the basis of the results obtained.

Fuel Oil---III

Use on Pacific Coast Steam Ships. By Charles W. Geiger

THE USE of fuel oil on steamships on the Pacific Coast is very important both from the commercial standpoint and from an engineering standpoint.

The commercial importance of the use of oil for marine power is shown by the fact that with the conversion of the Pacific Mail liner San Juan to an oil burner a short time ago, every American vessel now running out of San Francisco uses crude oil for fuel. The San Juan is the last of the nine large ocean liners owned by the Pacific Mail to be converted from coal burner to oil burner, all vessels being originally built for burning coal. Since their conversion to oil burners, the stoke hole staff has been reduced 50 per cent.

It required 75 days to convert the San Juan to an oil burner. The oil tanks installed in the bunker space have a capacity of 3300 bbl. of oil. The largest steamer

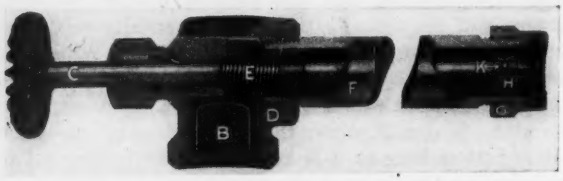


FIG. 18. QUICK ADJUSTING MECHANICAL TYPE OF OIL BURNER

in the fleet is the Colombia, which has been equipped with oil tanks with a capacity of 11,000 bbl. This vessel together with a number of other large vessels of the Pacific Mail fleet operate between San Francisco and the Orient. They take on fuel at Honolulu on the outbound trip, also at Hongkong, and again at Honolulu on the return trip, and at San Francisco for the following trip. One of the greatest advantages in the burning of oil, is the fact that the oil can be taken aboard the vessels in such a short time. In San Francisco the oil is pumped aboard at the rate of 1000 bbl. per hour. Another advantage is that less space is required for oil, than for coal, which, of course, gives greater space for freight. If a vessel was intended to run between San Francisco and some port where oil for the return trip could be had, the storage space would be approximately 56 per cent of that required for coal. Another fact in favor of the use of oil, is that coal must, for obvious reasons, be stored close to the boiler, while oil, being readily pumped from any point desired, may be stored in space not otherwise useful.

If a vessel plies to a port where oil for return fuel is available, the weight of oil carried is about 60 per cent of that of the equivalent coal. For every hundred tons (224,000 lb.) of coal consumed on the trip, 400 bbl. of oil would be required, weighing at 15 deg. gravity 337 lb. per barrel, or 134,800 lb. As the fuel is, generally at least, used in equal amounts every hour of the trip, both solid and liquid fuel carried would diminish in weight from the gross amount at the start to zero at the end of the trip, and the average weight carried would, of course, be half the initial weight, or 112,000 lb. for coal and 67,400 lb. for oil, making the weight of oil 60.2 per cent of weight of coal.

As would be expected from experience on land, the use of oil at sea is the means of increasing the speed capacity, and of extending the sailing radius. It reduces the labor in port, on cleaning both the outside and inside of boiler-room. In tropical climates it is a material factor that the fire-room temperature is considerably reduced, where oil is used, and the very hard labor of shoveling coal and slicing fires at high temperatures done away with. The economic advantage in using oil for fuel, is so manifest that those who have looked into the matter have usually adopted oil without much experiment. The following table will show at a glance the saving in oil over coal:

U. S. S. Golden Gate	80 per cent
U. S. S. Chinook	75 per cent
U. S. S. Clatsop	75 per cent
State Harbor Board's tugs Governor Irwin, and Governor Markham	75 per cent

The following data from the steam trials of U. S. R. C. Golden Gate made in November, 191', may be interesting:

Duration, hours	1.50	1.00
Water evaporated, totals for run, lb.	8332.00	8013.00
Total equivalent, from and at 212 deg. F., lb.	9798.43	9098.76
Fuel oil corrected for moisture, total lb.	614.90	600.00
Water per hour:		
Main engine and auxiliaries, lb.	5320.66	7664.50
Oil pump, lb.	87.00	98.00
Oil burners, lb.	147.00	250.50

Total for all purposes	5554.66	8013.00
Total equivalent, from and at 212 deg. F., lb.	6532.29	9098.76
Fuel oil corrected for moisture per hour, lb.	409.90	600.00
Evaporation, lb. water per lb. oil, lb.	13.55	13.35
Factor of evaporation, lb.	1.176	1.135
Evaporation, lb. water per lb. oil, equivalent lb.	15.99	15.16
Total heating surface, sq. ft.	2034.00	2034.00
Evaporation per sq. ft. heating surface per hour, equivalent., lb.	3.21	4.47
Per cent of total equivalent evaporation for atomizing oil	2.25	2.75
Efficiency of boiler, per cent	82.55	78.50
Pressure by gage:		
At boiler, lb.	145.00	144.00
At engine, lb.	135.00	133.00
First receiver, lb.	21.00	36.00
Second receiver, lb.	1.00	4.00
Vacuum, inches.	23.00	23.00
Oil to burner, lb.	45.00	45.00
Temperature average:		
Feed, deg. F.	89.00	125.00
Stack, deg. F.	453.00	516.00
Fuel oil to burners, deg. F.	124.00	128.00
Main engine, revolutions per minute.	125.90	147.60
Total horsepower, main engine and auxiliaries.	253.92	396.85
Horsepower of auxiliaries, estimated.	17.10	19.54
Water per hr. per hp. equivalent, lb.	24.65	21.82
Fuel oil per hr. per hp. total, lb.	1.61	1.51
Fuel oil per hr. per i.hp., lb.	1.73	1.58
Fuel oil:		
Specific gravity		0.952
Degrees, Baume		17.00
Flashpoint		190.00
Fire Point		280.
Calorific value, B.t.u.		18,648.00
Moisture		0.005

Wm. L. Maxwell, 2nd Lieut. of Engineers, U. S. R. C. S.

The above engine was not overhauled for fifteen years, which accounts for the high fuel consumption per horsepower-hour.

All vessels of the Pacific Mail line are equipped with burners in which the oil is atomized by mechanical means. One of the most important advantages derived from the use of the mechanical system of atomizing is that "make-up" feed water for the boilers can be reduced to a minimum, as no steam escapes up the stack.

The equipment necessary for the mechanical type of oil burner consists, primarily, of an oil pumping set of two duplicate duplex oil fitted pumps, connected up in such a manner as to allow of either pump being independently cut in or out of service; oil heaters in sufficient duplicate units to supply the maximum amount of heated oil with one or more units in reserve; duplex suction and discharge strainers—and the necessary number of firing fronts and burners.

The oil, after leaving the pump under pressure ranging from 30 to 200 lb. is passed through the oil heaters where it attains a temperature between 190 and 220 deg. F. At this temperature it enters the burner, which is constructed in such a manner as to impart to the oil a whirling motion of high velocity. The law of centrifugal force compels the whirling oil atoms, upon being released through the discharge orifice of the burner, to disintegrate and enter the furnace in a completely atomized condition.

The heating of the oil for this system is accomplished with live steam. The necessity for heating is, primarily, to reduce the viscosity of the oil, for as the atomizing of the fuel is accomplished by the centrifugal force imparted to it as it passes through the burner tip, the lower the viscosity of the oil the more readily it disintegrates.

The heater is constructed of wrought steel shells, wrought steel heads and seamless steel coils welded into one. The oil entering the heater unit between the two shells takes a spiral course upward to the space between the two shell heads from whence it flows down through the seamless steel coil and out to the discharge header. In the event of an operator closing the inlet and outlet oil valves without cutting out the steam to heater, thereby causing the dead oil in the unit to heat and expand to a pressure which might create a rupture, a safety valve is provided for each unit and set to operate before an excessive pressure can be attained. Batteries are installed of a sufficient number of units to allow of one or more units being held in reserve when full power is being developed.

The burner shown in Fig. 18 consists of a special angle valve, a short piece of tubing, a tip, a cap to hold the tip in place and a steel rod running through the burner to provide means for regulating the discharge from the tip. It is subject to immediate adjustment and control, so as to produce a light, medium or heavy fire without the necessity of changing the oil pressure at the pump. The change from one fire to the other can be made instantly without extinguishing the flame, altering the oil pressure or impairing the quality of the flame, thus the common method of taking care of a fluctuating load by cutting burners out and then relighting them is eliminated. With this burner, the fireman has at his immediate command, not only means for regulating the size of his operating fire, but means whereby he can instantly substitute a stand-by fire and vice versa, with one quick turn of the burner valve wheel.

This system is equipped with an automatic stopflow, and in the event of a break or fracture of a fuel oil line, the stopflow instantly and automatically cuts off the supply to any point in the line beyond its location and diverts the flow back to the tank or pump suction. When the valve trips, it remains closed until manually opened. It is provided with an indicator which enables the engineer or fireman to adjust it correctly to operate at any desired pressure. It can be instantly bypassed when necessary.

In operating this system, the fireman cracks the valve in the return line, starts the oil pump, admits steam to the oil heater and allows the oil to circulate through lines until the thermometer shows the proper temperature.

When the oil has attained the proper temperature he closes the valve in the return line, opens the dampers in firing front and stack, inserts a lighted torch directly in front of the burner tip, opens burner valve wide, and

opens the valve in burner feed line wide, when fires will readily light.

The fireman regulates the oil pressure at the pump —60 to 70 lb. to start with. After steam is up, he adjusts the oil pressure to suit the load. He adjusts the steam pressure to the heater at the reducing valve, and adjusts the dampers in firing front to admit the proper amount of air for combustion.

For the purpose of cutting out fires, he uses the valve in burner feed line.

All Pacific Mail vessels are equipped with Scotch Marine boilers. The oil used is of 18 deg. gravity.

As bearing on the economy incident to the substitution of liquid for solid fuel in marine work, figures have been obtained in regard to the fuel consumption of seven steamers plying on the bay and rivers, showing the fuel consumption for corresponding months in 1902 and 1903, the steamers having meanwhile been changed from coal to oil burners. The data were obtained from official sources, and may be entirely relied on.

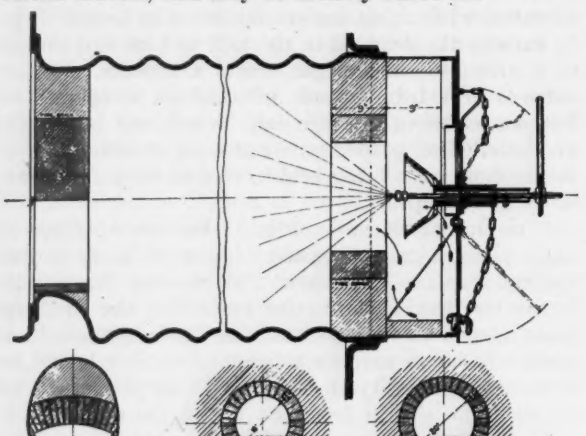


FIG. 19. METHOD OF BAFFLING IN SCOTCH MARINE TYPE BOILER, SHOWING SPECIAL FORM OF BRIDGE WALL

Fuel consumed:

	Coal, 1902		Oil, 1903		Miles Run		Fuel Per Mile Run Coal, 1902		Oil, 1903	
Steamer	Tons	Cost	Bbl.	Cost	1902	1903	Tons	Cost, Cts.	Bbl.	Cost, Cts.
No. 1	460¾	$3.65	1488¼	$0.60	3322	2996	.1387	50.6	.4967	29.8
No. 2	91	3.65	1224	.60	825	2730	.1103	40.3	.4484	26.9
No. 3	184	3.70	2559½	.60	4261	4284	.1606	74.7	.5975	31.6
	500	5.00								
No. 4	204	4.00	2060	.60	1703	4329	.1836	67.0	.4759	28.5
	108¾	5.00								
No. 5	91	3.00	1296¼	.60	2353	2353	.1539	54.8	.5505	33.0
	271¼	3.75								
No. 6	395¼	3.75	1222¾	.60	3635	3530	.1087	40.8	.3634	20.8
No. 7	373¼	3.75	1180½	.60	3730	3635	.1002	37.5	.3279	19.7

The California Transportation Co. operates the largest fleet of river boats on the Pacific Coast. These vessels ply between San Francisco and Stockton, and between Sacramento and San Francisco.

A description of the boiler room and oil burning system of one of the most recent of these steamers built, may be of interest.

The fuel oil is carried in two tanks with a capacity of 176 bbl. each. The steamer has a speed of 13 knots an hour, and averages 1100 mi. on 352 bbl. of fuel oil. A 3½-in. pipe connects the oil pumps with the oil tanks, the main pipe leading from the pumps to the burners being 1½ in. in diameter. There are two sets of duplex pumps 4½ by 3 by 4 in. The pumps operate just fast enough to turn over. The sets of pumps are used alternately for a week at a time, which gives a chance to make any necessary repairs, and for repacking. The pumps are operated on 45 lb. steam pressure and the oil is delivered to the burners at a pressure of 40 lb. There are two batteries of two straight horizontal boilers each, with one burner for each boiler. The working steam pressure is 160 lb. This entire equipment is tended to by one fireman on each watch.

There is a pan under each burner placed in the ashpit which catches all leaking oil which eliminates the possibility of oil accumulating, which might cause an explosion. These pans are inspected frequently, and if any oil has accumulated in them, they are taken out and the oil emptied.

The steamers arrive in San Francisco in the morning, at which time the burners are shut down; but as it is necessary to maintain a head of steam in the boilers throughout the day, for the use of the donkey engines and for cooking purposes, the burners are started again at 1 o'clock and operated for about 15 min.

At 5:15 in the evening, the burners are again lighted and steam raised to 160 lb. ready for the voyage which starts at 6:30. Steam can be raised in the cold boilers in about 1 hr.

The bay and ferry steamers of the Southern Pacific, Western Pacific, Santa Fe, Key Route, Northwestern Pacific burn oil exclusively, with the most satisfactory results. The change from coal to oil burning (in these vessels which were not originally built as oil burners) involved merely the building of tanks in the coal-bunker space, the installation of the necessary pumps, etc., and the substitution of bricks on grates to control the incoming air.

Equipment on Steamer Berkley

Below will be found a description of the boiler-room and fuel-oil plant on the steamer Berkley running between San Francisco and Oakland Mole.

The Berkley is a propeller boat of 1245 tons, length 260 ft., beam 40 ft. and draft 8 ft. 9 in. The propellers, one at each end of the boat, are 8 ft. in diameter, 14 ft. pitch, with 34 sq. ft. of surface. The engines are triple expansion, the cylinders being 22, 34 and 56 in. respectively, with 36-in. stroke, using steam at 165 lb. in high pressure, condensing at 26 in. vacuum through 1824 5/8-in. brass tubes, having 2475 sq. ft. of cooling surface.

The boilers are four in number, placed end to end in pairs, with continuous furnaces. Boilers are internally fired, two corrugated furnaces to the boiler, the total heating surface being 4820 sq. ft. Forced draft is used, air being forced by a fan through a series of pipes placed in the uptake, where it is heated to approximately the temperature of flue gases. The air pressure maintained is sufficient to balance the draft, water gage on ashpit fluctuating somewhat, but showing on an average neither pressure nor vacuum.

The fuel oil is stored in four upright cylindrical tanks, placed at ends of the old coal spaces. The bunkers, two in numbers, are 8 by 14 by 38 ft. The tanks, which are of 3/16-in. steel, with flat bottoms and tops, with vent pipe through side of vessel, hold 2750 gal. each. They are connected in pairs with the main oil

feed, the pipes entering tanks about one foot from the bottom, and being provided with independent valves to prevent passage of oil from one tank to another in case of listing or heavy rolling.

From the tanks, the cold oil passes to the pumps, of which there are two—one in use, the other held in reserve. The pumps are of the duplex piston pattern, 4½ by 2¾ by 4 in. The oil is discharged through a spring governed regulator, bypassed into the suction, into the pressure tank, a cylinder about 18 in. in diameter and 5 ft. high. The air cushion in this tank is maintained by occasionally pumping in air against oil pressure, and takes up the pulsations of the pump, oil entering and leaving the tank from sides near the bottom. From the pressure tank the oil passes to the heater, consisting of a cylinder 5 ft. high and 8 in. in diameter, with a single 1½-in. pipe passing up through the center, through which passes the exhaust steam from the oil pump. The oil entering the heater at the bottom is heated to about 70 deg. F. before being discharged from the top into a strainer of fine wire gauze, passing from the strainer to the main burner supply.

The burners are an inside mixing burner of the tubular type. The atomizing agent is steam at boiler pressure, 165 lb., controlled by a globe valve; oil is taken to the burner at 45 lb., and controlled by a globe valve. As this ferry steamer makes a landing and a 10-min. stop every 30 min., it is necessary that the fires should be readily stopped and started, and in practice a single movement of the oil cock lever, the opening of air valve, and a slight adjustment of steam supply, are all that is required, the oil igniting readily from the brickwork in the furnace, and the steam only requiring adjustment, and that very little. The oil supply is run steadily at full opening; if necessary to regulate the flow of oil, this is done, not by turning the lever, but by altering the width of opening of the cock, the oil passage through the plug being of inverted V shape, and regulated by an interior sleeve by which the orifice may be partially or entirely closed. It is thus possible to run always with the oil cock wide open, when if necessary to alter the rate of flow for any reason, which seldom occurs, the adjustment may readily be effected from the outside, without stopping the flow or altering the position of the lever.

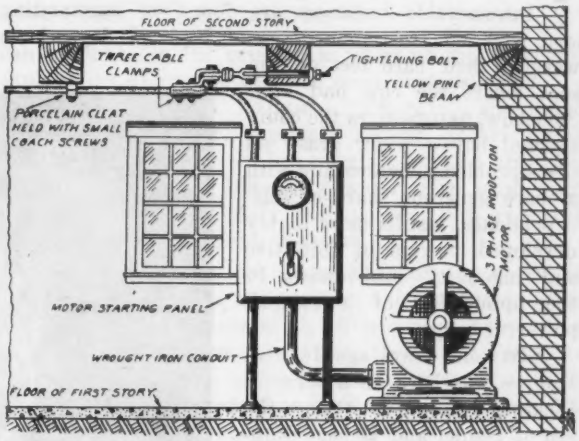
The furnaces are lined from end to end with a single course of firebrick, extending halfway up the side. About 3 ft. back of the door is placed a checker wall of firebrick, reaching rather more than halfway up the furnace, and 2 ft. farther back another wall of similar construction and height. The burner is entered near the bottom of the firebox, and set level, the flame striking against and through the checker walls, the object being to distribute the heat more uniformly through the furnace than can be done with a naked flame. The boilers being fired from both ends have a common combustion chamber, but on installing oil burners this combustion chamber was divided by a light wall of firebrick, placed crosswise, and reaching within an inch of the top of the chamber, thus making each boiler independent.

The experience of the Southern Pacific Co. in the use of fuel oil on steamers, has been entirely satisfactory. Labor has been decreased, dust from handling coal and ashes entirely done away with, fire-room temperature lowered (though temperature in uptakes is higher than when using coal), time in loading has been diminished (the Berkley takes on oil once in two days) and a great economy in fuel costs was realized.

Dead-Ending Motor Leads

By Roy J. Turner

A CONVENIENT and economical method of dead-ending large, slow-burning insulation conductors on the floor timbers of a wood-frame building over the switchboard for a motor is indicated in the accompanying illustration. The cable clamps in combination with an I-bolt provide a means whereby the conductors can be drawn taut, and their application renders unnecessary any "making up" of the heavy conductors. No copper is wasted in making such a termination.



METHOD OF TERMINATING LEADS FEEDING AN INDUCTION MOTOR

A young Danish teacher living in the United States when the war broke out joined the American Expeditionary Forces. A severe injury received from a high explosive shell at Chateau Thierry resulted in the amputation of his leg. His limited knowledge of English, together with his physical disability, seemed, in the opinion of the vocational advisers of the Federal Board, to whom he applied for help, too great a handicap for him to make a success in his old profession of teaching, but he was keen about "carrying on." After carefully going over his educational stock-in-trade, he agreed to study architectural drawing. Timid at first because of his inability to speak and understand English, he is now studying at the Chicago Technical College, qualifying for an advanced course later.

The United States Shipping Board announces that, as result of statement made public Sept. 29 by Division of Operations, and in which it was shown that Europe, despite its dire need for coal, was diverting its own tonnage to the more profitable trade routes, leaving to America the job of carrying the less profitable coal cargoes to Europe, the Danish Legation announced, Oct. 9, that 16 steamships are to be placed in coal trade and will carry coal from this country to Denmark.

JOHN J. HOPPES

LONG A STUDENT OF POWER PLANT SUBJECTS, AN INVENTOR, SUCCESSFUL MANUFACTURER, AND USEFUL CITIZEN. BY WALTER PAINTER

TO BE BORN and raised on a farm seems to be one of the old-fashioned requisites of a successful career. Innumerable instances are found of outstanding men who, on frosty mornings of boyhood days, have warmed their bare feet on the spot where the cow had lain. Somehow, nature gives the countrybred boy a wider grasp on life's problems, endows him with a more generous share of self-dependence, instills more highly developed powers of initiative and ingenuity, and assists in the upbuilding of a rugged, powerful body.

John J. Hoppes

Sixty-one years ago John J. Hoppes was born on a farm in Pickaway County, Ohio, the son of Daniel and Helen (Stanton) Hoppes. His father was a contractor engaged in building operations, most of which were flour mills scattered about central Ohio.

At the age of 12, young Hoppes began to help his father, and four years later during his father's illness he took over the contracts. For about two years, he was engaged in the construction and operation of these mills, steam and water driven. In this capacity, he did everything from landscape gardening to engine operating, but made this experience count.

As a young man, he was always quiet, thoughtful and studious and at 16 yr. passed a teacher's examination, although his youth prevented an assignment. Joined to this keen ability to acquire knowledge readily was the inherent fascination which the pleasant, rhythmic clicking of a Corliss valve gear and the humming of wheels held for him, and big desire to understand better the diversified phases of power plant engineering.

Possessed with a compelling desire to take up engineering studies, he decided to enter Stevens Institute of Technology and had some correspondence with Dr. R. H. Thurston with that end in view, but owing to his father's illness, it became impossible for him to carry out this ambition. Dr. Thurston, however, had become interested in Hoppes, and offered to help the young man with a personal correspondence course of instruction which was gladly accepted. He continued this course for about 5 yr. and attributes much of his success to the fundamental guidance of Dr. Thurston.

Very early in life he took up the study of physics, which greatly appealed to him. His copy of Quackenbos' Natural Philosophy with its well thumbed pages is still treasured on his book shelf.

Eventually he began to specialize in designing and rebuilding steam plants, and also acting as consulting engineer in a small way to power users.

Soon his inventive and constructive talents became active, and subsequently his attention was directed chiefly to developing steam specialties.

In 1882 he designed a feed-water heater and in 1885 a live-steam feed-water purifier. Nature's phenomena furnished him his first inspiration in designing this purifier. He noticed how the dripping of water from the roofs of natural caverns caused the formation of stalactites and conceived the idea of employing this principle in an apparatus for heating and purifying boiler feed water by means of live steam. Later he applied this same scheme to an exhaust steam feed-water heater.

Next he designed a new form of steam separator employing troughs partly filled with water to intercept the entrainment. He also applied this principle to exhaust pipe heads.

One of the mast recent pieces of power plant apparatus developed by Mr. Hoppes is a V-Notch water meter, in which the height of the water is weighed in the ratio of the rate of flow.

Mr. Hoppes is married, and his principal recreations are boating and motoring—when he can find the time. Back in 1903 he designed and built a 75-ft. steel house-boat launch which included many features new at that time.

Civic improvement is another avocation. Springfield, Ohio, in 1915 adopted the commission form of

government and Mr. Hoppes was one of those elected to draft the charter and afterwards elected one of the City Commissioners which position he still holds. The elimination of overhead wiring, repaving, a comprehensive sewage system, and numerous improvements made by the city formed a large part of his work in this line.

He was the principal organizer in the formation of the National Improvement Association and was its first presiding officer. Later this association was changed to the National Civic League.

For 29 yr. he has been a member of the A. S. M. E. as also a member of the Ohio Engineering Society and the National Association of Stationary Engineers.

"Serve faithfully and well," says Mr. Hoppes. "The young engineer who is best qualified to assume wider responsibilities, who is ticketed for the chief engineer's or superintendent's chair is the fellow who has given a good account of himself. To have served well in the past is the most worthy assurance of serving well in the future."

Pitting and Corrosion in Boilers and Economizers*

THREE COMMON THEORIES OF CORROSION CAUSES, EXAMPLES OF PITTING, EFFECTIVE PREVENTIVES AND CURES. BY F. F. VATER

THREE theoretical causes of corrosion are given, as follows:

1st. The carbonic acid theory is based on the premises that all corrosion is caused by acids either weak or strong, the iron being first converted to a ferrous salt with the escape of free hydrogen. Under the influence of oxygen and water the ferrous salt is oxidized to ferric hydroxide (insoluble) releasing carbonic acid which again attacks the metal. The process therefore, is continuous if any carbonic acid is present.

2nd. The hydrogen peroxide theory of "Traube." This assumes that when iron, water and oxygen are in contact a reaction takes place in which ferrous oxide and hydrogen peroxide are formed. The ferrous oxide then reacts with one-half of the hydrogen peroxide to form a basic or hydrated oxide; rust, an insoluble basic oxide, is the final product. Part of the excess of peroxide then acts on more iron, forming ferrous oxide and water whereupon more of the peroxide reacts with the iron compound to produce more basic oxide, and so the process is repeated indefinitely.

3rd. The electrolytic theory is based upon the premise that all reactions which take place in the wet way are attended with certain readjustments of the electrical states of the reacting ions. Under this theory, before iron or steel can oxidize in the wet way it must first pass into solution as a ferrous ion.

When a strip of metallic iron is placed in a solution of copper sulphate, iron passes into solution and copper is deposited, this change being accompanied by a transfer of electrical charge from the ions of copper to those of iron.

Quoting from A. S. Cushman, Asst. Director, Office of Public Roads: "Hydrogen acts as a metal and is electrolytically classed with copper in relation to iron. If therefore, we immerse a strip of iron in a solution containing hydrogen ions, an exactly similar reaction will take place; iron will go into solution and hydrogen will pass from the electrically charged or ionic to the atomic or gaseous conditions." Quoting Cushman again: "It is very well known that solutions of ferrous salts as well as freshly precipitated ferrous hydroxide are rapidly oxidized by the free oxygen of the air to the ferric condition, so that if the electrolytic theory can account for the original solution of the iron, the explanation of rusting becomes exceedingly simple."

Quoting from L. C. Wilson: "When iron and water are brought together, a certain amount of the metal goes into solution, since it has a certain solution pressure, or, to put it a little differently, water, even when very pure, is dissociated slightly into hydrogen and hydroxyl ions, the former attacking the iron.

"It can be shown that the solution tension varies at the different parts of the surface; this variation being due to strains and segregation of impurities; impurities in the solvent also tend to increase the solution tension. Therefore, the points where this is the greatest will be positive to those at which it is of lesser degree, and a current will flow between them if there is a conducting medium present.

"Remembering that hydrogen acts like a metal, it is seen that its ions will tend to collect around the negative poles, while the hydroxyl ions will move toward the positive poles and try to exchange their static charges with the iron, so that the latter will go into solution and the hydrogen escape as a gas.

"If the hydrogen ions are in sufficient concentration, that is, if an acid is present, this exchange of charges takes place very rapidly and the iron is quickly dissolved."

It is a well-known fact that water is the great solvent. There are few bases or compounds that are completely insoluble. It is also a well-known fact that iron and steel are by no means chemically pure.

ILLUSTRATIVE EXAMPLES

EXTENDING into a river is a suction line of 8-in. pipe. Its length is 400 ft. One length only of this pipe pitted through on the bottom. If it were carbonic acid or peroxide of hydrogen, why did not other lengths pit? Under the electrolytic theory the reason for pitting in this one section could be due to the impurity in the metal of which the pipe was made and in the water setting up the electrolytic action.

In 1916 there was quite a stir caused by Mr. Babcock's article concerning the serious pitting of the boilers at the Fruitvale Power House of the Southern Pacific Railroad.

If pitting was caused by either the carbonic acid or peroxide of hydrogen theories, why did the use of

*From a paper presented at the 1919 convention, National District Heating Association.

Navy Boiler Compound cure the trouble? The application of a galvanometer proved the existence of difference in potential between the water in the boilers and the metal they were made of.

In this society's proceedings of 1916, page 205, will be found a reference to a serious case of boiler tube pitting experienced by a western railroad where their chemist proved satisfactorily to the tube manufacturers that impurity in the metal set up electrolysis—proved it so positively that $26,000 was refunded by the tube manufacturers.

Mention has been made of two contributory causes, viz.: Impurity in the metal and impurity in the water.

There is another one, viz.: Sluggish or stagnant water. Iron will decompose much more rapidly where no currents exist than it will if the water is in rapid circulation. The writer visited a steel plant where Stirling water tube boilers were in service. They were of the five-drum type. The only place in the boilers showing decomposition was in the upper drum where the water entered. Pitting occurred in the drums at the extreme ends of the shell where there was the least current.

The pitting existed when an untreated or unsoftened water was used. It continued after a softener was installed. Various methods were tried to stop the trouble including the application of a storage battery current applied to an anode placed in the drum and connection was made to the shell of the drum to form a cathode. This did not remedy the trouble. Then, an anti-corrosive compound was fed into the water. It helped some but the last inspection showed the old pits were alive. Some of them were large enough and deep enough to place a half dollar in them.

Sugar is a preventive. The anti-pitting compound referred to above is largely glucose and it has been a distinct help. The perfect cure has not been found.

Another case: Electric Railway Power House, 10 boilers water tube type, double steam drums—One drum only out of 20 pitted. The pitting was very shallow. This was a case of electrolysis. The plate of which the drum was built was probably rolled too hot and the surface was burned. These were "scale pits" and the decomposition stopped as soon as the unburned metal was reached.

Another case: A plant containing ten 250 hp. water tube boilers with cast iron headers and two 500 hp. with wrought headers. A careful examination showed slight decomposition in the tubes when they were expanded into the cast-iron headers. There was no evidence whatever of decomposition in the boilers having the wrought headers. The difference in potential between the wrought metal in the tubes and the cast metal in the headers accounts for the trouble.

Another case: A Street Railway Power House selling exhaust steam for heating. A rapid decomposition of the underground piping was taking place. The meters would stop up in a short time with the iron rust or sludge. Several analyses were made and iron oxide was reported. There the question was asked what more did the sludge contain than iron oxide? An examination for copper was made and it was found. The trouble was located in the bonding of the rails. The bonds were in bad condition and the steam main was returning the current to the station. The presence of copper proved aggravated electrolysis. Rebonding the rails cured the trouble.

Preventives

"An ounce of prevention is better than a pound of cure." Demand purer steel in the construction of your boilers and piping. Use as pure water as possible for making steam. Especially, avoid waters high in sodium salts. Avoid the use of waters containing magnesium sulphate unless you have a good water softener treating the water to below 2½ grains per gallon hardness.

Cures

The cure is hard to prescribe. A cure under one condition will not necessarily prove a cure under another. Watch your boilers closely. Once well under way, pitting is difficult to stop.

Injecting an oxidizing agent, such as potassium bichromate, 8 parts in 100,000 parts of water or about 2 lb. to 3000 gal., has so far as known, never failed. However, since the war the price of potassium bichromate has been practically prohibitive except in very serious cases. For protecting boilers, where evaporation is taking place and new water entering, to maintain this strength continuously will be very costly.

Use of Navy Boiler Compound was successful at the Fruitvale Power House referred to above, but any highly alkaline compound would probably have done as well.

Pitting has been permanently stopped in cold water tanks by cleaning them and painting with one coat of quick-setting, Smooth-on iron cement.

Before applying any preventive, clean the pits out thoroughly.

Filling the pits with a mixture of one-half cement and one-half tar will many times effect a cure.

Painting the surfaces with Black Strap (low grade) molasses and burning it to carbon with a plumber's torch, will sometimes effect a cure.

You can determine whether or not a pit is active by removing it with the point of a penknife or awl. If the metal under the crown is silver, it is active; if black, it is dead.

U. S. Geological Survey states in summary of crude petroleum statistics for August, 1919, and preceding months, that the quantity of crude petroleum run from wells and producers' field storage tanks and delivered to pipe lines, marketing companies, refineries and other consumers in the United States in August, 1919, amounted to approximately 33,986,000 bbl., an increase of 465,000 bbl., or 1.4 per cent, compared with July, 1919, preceding record month, and 3,341,000 bbl., or about 11 per cent, compared with August, 1918.

It is announced from Ottawa that the Canadian Commission of Conservation has surveyed the coal situation in Canada with reference to possible coal shortage. Up to June 7, 1919, total production of anthracite was only 33,349,500 net tons, compared with 42,858,000 tons in the corresponding period of 1918, a decrease of 22 per cent. The shortage is partially due to migration to Europe of tens of thousands of Jugo-Slavs, Czecho-Slovaks, Hungarians, Poles and others.

Compound Engines

LOSSES PREVENTED AND ECONOMY SECURED BY USE OF TWO CYLINDERS; POWER AVAILABLE AND METHOD OF DIVIDING LOAD

AMONG the various losses occurring in a steam engine of the reciprocating type is that due to condensation (generally termed "initial condensation") and re-evaporation. It is obvious that the temperature of the inner cylinder walls corresponds very closely to that of the contained steam and as a consequence when steam at high pressure is admitted to a cylinder from which steam at a much lower pressure has just been discharged, a transfer of heat will take place from the incoming steam to the iron walls. This action results in the condensation of a portion of the steam without any work being done and a consumption of an excess amount of steam until that point of the stroke is reached when both steam and inner cylinder walls are at a like temperature. Continued expansion accompanied by a reduction in pressure, and therefore a lowering in temperature of the steam, brings about an increasing difference in temperature between the steam and the inner cylinder walls, the effect of which is to cause a re-evaporation of the condensate. This continues throughout the exhaust stroke and as ordinarily re-evaporation is not completed by the time the cylinder is ready to receive steam again, the moisture present has a tendency toward increased condensation of the new charge.

In engines, the loss due to initial condensation and re-evaporation may range from 10 to 20 per cent while in small reciprocating pumps it frequently amounts to from 60 to 75 per cent.

FACTORS AFFECTING CONDENSATION

DEGREE of cylinder condensation is dependent upon the rate of travel of the engine piston, the ratio of the area of the cylinder walls to the volume of the cylinder, the ratio of expansion and primarily to the range of temperature within the cylinder.

In slow-speed engines, the time from admission to exhaust is greater than in the case of high-speed machines, and as may therefore be expected, due to the increased time element, the loss brought about by condensation and re-evaporation is in excess of that occurring in a slow-speed engine. This likewise holds true in an engine in which the ratio of cylinder wall area to cylinder volume is great.

Economy in the use of steam in a reciprocating engine is dependent upon the degree of expansion employed and as it is desirable to operate with the greatest degree of expansion possible, or in other words, within a maximum range of temperature, it is apparent that to realize such conditions increase of losses due to initial condensation and re-evaporation will be encountered. This, however, must be avoided and in order to do so and at the same time realize the advantages accompanying the expansive use of steam, the total expansion is made to occur in two or more parts, or as it is ordinarily termed, by "compounding." To accomplish this, the steam is successively passed through two or more cylinders, the scheme of arrangement employed being such as will allow but partial expansion in each of the cylinders.

EXPANSION OF STEAM

IN THE ideal indicator diagram shown in Fig. 1 and in which as may be seen the steam is made to expand along an ideal expansion line from 120 to 1.6 lb. absolute pressure and that within a single cylinder having no clearance, AB represents the admission line. This is short in comparison to H F, which represents not only the length of stroke, but also the volume of steam after expansion.

A little study of this diagram will reveal the fact that where such a degree of expansion occurs within a single cylinder that cylinder will have to be so constructed as to render it capable of withstanding a maximum pressure of 120 lb. absolute and of such size as will accommodate the volume of steam represented by line H F. This is objectionable for two reasons. First, excessive friction is encountered in such large cylinders,

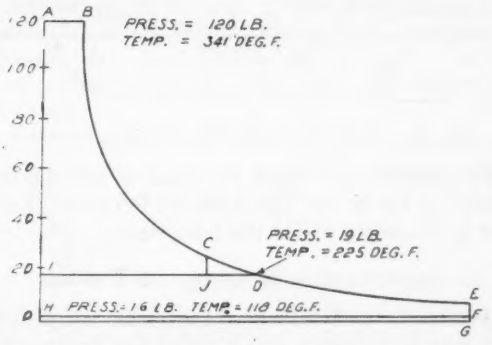


FIG. 1. IDEAL DIAGRAM ILLUSTRATING USE OF TWO CYLINDERS

and second, due to the amount of cylinder-wall surface exposed to the action of the exhaust steam condensation is excessive. In addition, the cost of casting and machining such a cylinder is prohibitive.

If, however, instead of having but a single cylinder the ideal performance represented by diagram ABEFH, two cylinders are employed each doing one-half the work of the large one or one doing the work represented by diagram ABCJI and the other by diagram IDEFH, somewhat different conditions and results will prevail. While, of course, as before, the one cylinder will have to be so constructed as to enable it to withstand a maximum pressure of 120 lb. absolute, its required size will be only such as to have a capacity as represented by line IJ. (Release is assumed to occur at C in order to have sufficient pressure at this point of the stroke to force the steam out of the first cylinder.) On the other hand, the volume of the second cylinder will be the same as that in which the expansion from D to E takes place; but, due to the fact that as the steam entering this cylinder is at a pressure of less than 20 lb. (19 lb.), as heavy construction is not called for.

What then is gained by the use of two cylinders instead of a single large one? It is true that more complicated and therefore more expensive mechanism is required, and that due to this added mechanism greater frictional losses are encountered, but spite of this other gains are realized. Where but one large cylinder is employed and where as in this particular case, the steam is admitted at 120 lb. absolute and exhausted at 1.6 lb. absolute, the temperature range is from 341 to 118 deg. F. or 223 deg. F., which, together with the comparatively large exposed cylinder wall surface, results in excessive condensation. With two cylinders, however, the exposed wall surface is less and the temperature range in each cylinder is but approximately half of 223 deg. F., or 112 deg. F., thus reducing materially the heat loss occasioned by condensation and re-evaporation.

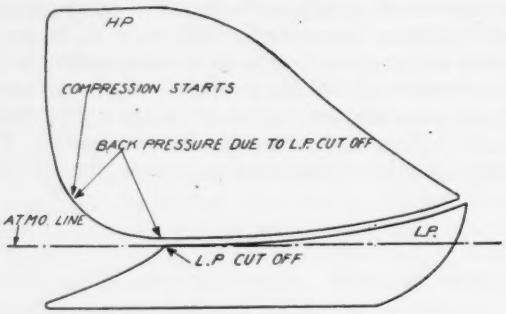


FIG. 2. TANDEM-COMPOUND ENGINE DIAGRAM

The cylinder into which the steam is first introduced is referred to as the high-pressure cylinder while the other is commonly called the low-pressure cylinder.

Classification of Compound Engines

According to cylinder arrangement, compound engines may be placed in either one of two groups, that is, tandem or cross compound. In the former, as the name implies, one cylinder is placed back of the other with the two pistons mounted on a common rod which, as in the case of all engines not of the trunk piston type, is joined to the connecting rod through the medium of a crosshead.

Cross-compound engines have their cylinders placed parallel one to the other with both sides acting on the same crankshaft. As a rule, the cranks are placed at 90 deg. in order to insure a more uniform turning moment and facilitate starting. With this arrangement, however, due to the events in the two cylinders occurring at intervals of one-fourth of a revolution the amount of steam exhausted by the high-pressure cylinders is not at all times the same as that required by the low pressure cylinder, and as a consequence, a reservoir or so-called receiver is placed between them to insure a continuous supply of steam to the low-pressure side and as far as possible to provide against any excess back pressure in the high-pressure side.

Such receivers are not required in tandem-compound engines; this because of the unison in movement of the two pistons, allowing the direct discharge of the steam from one cylinder to the other.

Action of the steam in the cylinders of a typical tandem-compound engine is indicated in the cards shown in Fig. 2. In this particular case, it will be noted that low-pressure cutoff takes place at a point somewhat beyond midstroke and before compression occurs in the high-pressure cylinder. At this point, however, exhaust from the high side is as yet not complete, and as a consequence, a back pressure is created in the manner shown.

Increase of pressure in the pipe joining the two cylinders of a compound engine depends upon the point of cutoff in the low-pressure cylinder. Where this occurs early in the stroke, the pressure is greater than where cutoff occurs later and in order to avoid loss of power, cutoff in the low-pressure cylinder must be so timed as to provide a pressure at the beginning of compression equal to that at the time of opening of the high-pressure exhaust valve.

Action of Steam in Cross-Compound Engines

In order to explain most readily the action of steam in the cylinders of a cross-compound engine having cranks placed at 90 deg., the cards have been arranged in the manner indicated in Fig. 3. Due to this arrangement and the consequent sequence of events, admission of steam to the low-pressure cylinder occurs at a point corresponding to mid-stroke of the high-pressure piston. It will therefore be noted that the high-pressure exhaust, instead of being constant in value throughout the exhaust stroke, due to the closure of the low-pressure steam valves and the entrapment of the steam within the receiver, is built up, increasing up to the point at which the low-pressure steam valve opens. The steam is taken from the receiver and, as indicated, the high-pressure exhaust line curves downward until the high-pressure exhaust valve closes and compression starts.

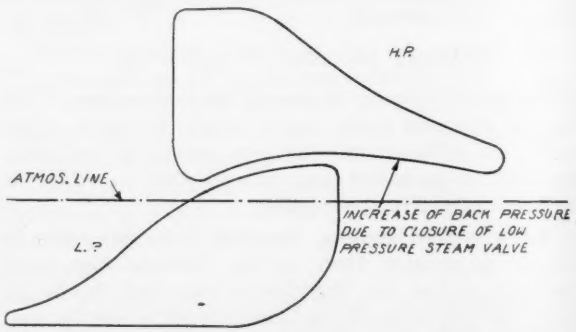


FIG. 3. DIAGRAM OF CROSS COMPOUND ENGINE WITH CRANKS DISPLACED 90 DEG.

Cutoff in the low-pressure cylinder in this particular case takes place before mid-point of the stroke is reached. When, however, the valves of the engine are so set as to retard cutoff to a point beyond mid-stroke of the low-pressure cylinder, the high-pressure cylinder will have started on its return stroke, the exhaust from the other end will have begun to enter the receiver and so-called "second admission" occurs. The effect of this action is to cause a rise in the expansion line of the low-pressure card as shown in Fig. 4.

Power of Compound Engines

Ratio of expansion, or the number of times the steam is expanded, is the factor governing the power developed by any engine whether simple or compound. While in the former type this expansion is made to occur in a single cylinder in a compound engine, it is divided between the two cylinders.

While for exact results due consideration must be given the clearance volume, for all practical purposes it is possible to determine the approximate ratio of expansion in a compound engine by multiplying the ratio of expansion in the high-pressure cylinder by the ratio of volume between the high- and that of the low-pressure cylinder. That is, if for example, cutoff occurs in the high-pressure cylinder at 1/5 stroke and the volume of the low-pressure cylinder is three times that of the high-pressure cylinder, the steam is expanded about five times in the high-pressure cylinder while the total expansion is therefore equal to five times three, or fifteen. With cutoff occurring at 1/15 of the stroke, this same degree of expansion could be realized in the low-pressure cylinder alone.

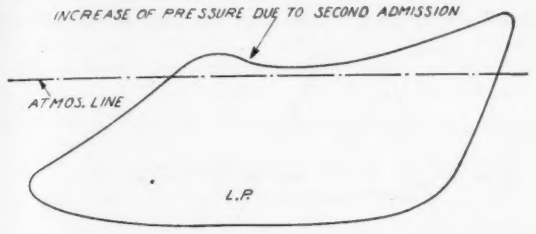


Fig. 4. Effect of second admission on low-pressure card

It is therefore apparent from the above that the total power developed by a compound engine is dependent upon the ratio of the cylinder volumes and the point of cutoff in the high-pressure cylinder but, as in any given engine, the ratio of cylinder volumes is a fixed quantity, the power developed is entirely dependent upon the point of cutoff on the high-pressure side.

The horsepower developed by a compound engine may be determined by means of indicator cards taken from the high- and low-pressure sides simultaneously. That developed by each cylinder is equal to the quotient obtained by dividing the product of the mean effective pressure in pounds per square inch, the length of stroke in feet, the area of the piston in square inches and the number of strokes per minute, by 33,000. The sum of these two quotients is the number of horsepower developed by the engine.

Distribution of Load

By changing the point of cutoff in the low-pressure cylinder the proportion of load carried by each side may be as desired or required; early cutoff will throw more of the load on the low-pressure side, while late cutoff will tend to cause the high-pressure cylinder to take more. This is apparent from the fact that by providing an earlier low-pressure cutoff the high-pressure cylinder is made to work against an increased back pressure with the result that the work done is reduced and more thrown on the low-pressure side. Giving the low-pressure side a later cutoff decreases this back pressure against the high-pressure piston and, as a consequence, more work is done by this side and less by the low-pressure cylinder.

Lubricating Ammonia Compressors*

To perform its functions properly, a lubricating oil should have body sufficient to keep bearing surfaces apart; should reduce friction to a minimum; should remain fluid at the lowest temperatures to be met in service; should not decompose and form deposits that will gum up the machinery; should have no ingredients which can corrode or pit metal, and should have flash point high enough to insure against the presence of volatile constituents.

To avoid vaporizing too quickly under the high compression heat in an ammonia compressor cylinder, a lubricant must have a good flash, say, 325 deg. F., and as some oil in vapor form is likely to be carried into condenser pipes with the ammonia gas, the cold test should be low enough so that the lubricant will not solidify in the piping and coils—5 to 10 deg. F. If it is carried on through with the liquid ammonia, it can be taken out by an oil trap, placed ahead of the liquid receiver and at the lowest point in the expansion and condenser coils. Such a trap may be made of a piece of 4-in. piping, 2 ft. long, with a draw-off connection at the bottom.

If the lubricating oil gets into the condenser coils and stays there, it can be loosened by cutting off the water from one stand at a time, allowing the coil to become hot, so that the oil is thinned and will run off into the oil trap.

Oil carried over, and collecting in the condenser and expansion coils, is a source of lost capacity, and is frequently due to locating the oil separator too close to the compressor discharge, where the gases are hot and the oil mostly in vapor form. Placing the separator near the condenser gives time for the gases to cool somewhat before reaching it, so that the oil is partly condensed and is more readily separated.

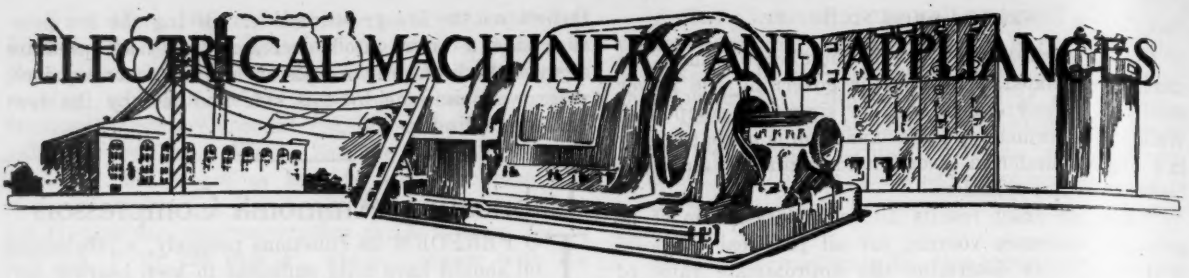
All oil used for the compressor cylinder should be measured and a record kept. Any unusual increase in the amount fed should lead to an immediate investigation to prevent filling of the system.

As hot ammonia gas has a bad effect on stuffing box packing, a liberal supply of oil should be applied to the piston rod in the stuffing box to reduce the chance for overheating.

Discoloration in the ice is not always due to oil. Two cases were mentioned in the discussion, one where firebrick was used to fill an open heater in which there were no flow pans, and the mineral matter from the brick carried over into the ice; the other where rust from a fore cooler caused the trouble, which was remedied by painting the inside of the fore cooler.

If you could be an entirely new man over night, how much better a one would you be in the morning?

* Paper and discussion, Nat. Assn. Prac. Refrig. Engrs.



A Study of Dynamo Electric Machinery---VIII

ELEMENTS OF ALTERNATING CURRENTS; INDUCTANCE, CAPACITY AND POWER FACTOR. BY OTTOMAR H. HENSCHEL

REVIEWING the underlying principles of the elementary electric generator with its bi-polar field and single-coil armature, we find that the electromotive force generated reverses in direction twice during each revolution of the coil, and that if instead of equipping such a machine with a commutator, the armature coil be connected to collector rings, the rise and fall and reversal of direction of electromotive force in the circuit supplied will be similar to that in the coil. A graphic representation of this is illustrated in Fig. 49. For sake of convenience, the values above the horizontal axis may be designated positive, and those below this axis, negative; a complete set of such values is termed

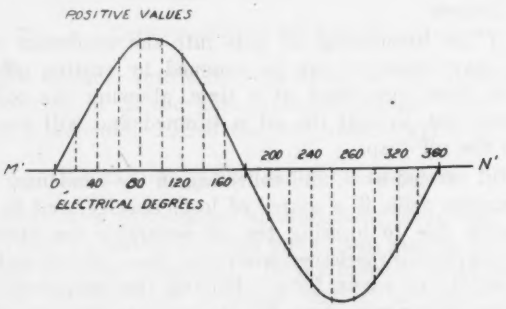


FIG. 49. INDICATING THE RISE AND FALL AND REVERSAL OF DIRECTION OF ELECTROMOTIVE FORCE INDUCED WITHIN THE WINDINGS OF A SINGLE-COIL ARMATURE REVOLVING BETWEEN THE POLE PIECES OF A BIPOLAR GENERATOR

a cycle. The time duration of a cycle is termed a period and the number of cycles occurring a second is called frequency. In a simple alternating-current generator, having but one north and one south pole, and a single-coil armature, a complete cycle is passed through each time the armature makes one revolution, so that if the number of poles of any such machine is represented by p and the number of revolutions per second by n, the number of cycles per second or frequency f is equal to the product of p times n, divided by 2, or $f = p\,n \div 2$.

When the armature coils of an alternating-current generator are connected in series and the circuit thus formed terminates in two collector rings mounted upon the shaft, but insulated from it and from one another, the winding is said to be single-phase and the machine is called a single-phase generator. In order, however, to meet the requirements of the polyphase induction motor and the rotary converter, it is necessary to equip alternating-current generator armatures with windings, such as will deliver polyphase (that is, more than one-phase), currents. This may be either two-phase or three-phase. In a two-phase machine, there are two sets of coils, the first set cutting the magnetic field at a maximum rate, when the induced electromotive force in the second set is zero; these electromotive forces are separated in phase by a quarter period or 90 deg., as shown at A, Fig. 50. At B of this same figure are shown the electromotive forces when the phase difference is 120 deg.

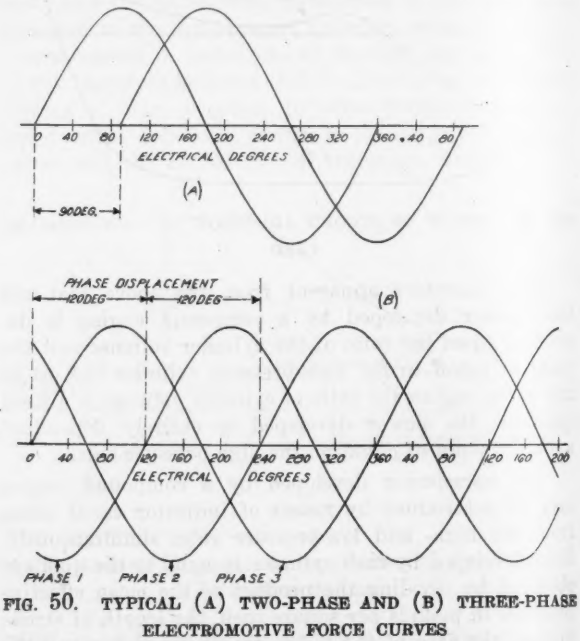


FIG. 50. TYPICAL (A) TWO-PHASE AND (B) THREE-PHASE ELECTROMOTIVE FORCE CURVES

MAXIMUM AVERAGE AND EFFECTIVE VALUES

THE IDEAL alternating electromotive force and current curve is the so-called sine curve, which may be readily constructed as indicated in Fig. 51. Upon the horizontal base line is drawn a circle having a radius O A and divided by means of radii O A, O B, etc., to O L, the spacing employed in this particular instance being 30 deg. Perpendiculars to the horizontal base line are dropped from the intersections of these various radii with the circumference of the circle as P B, Q C, O D

and so forth. If now along the horizontal base line, as at the right of the figure, a given length of this line be laid off and divided into 12 equal parts, each to represent 30 deg. and perpendiculars erected corresponding in length to those at the left, that is B′P′ equal to B P, C′Q′ equal to C Q, etc., and the various points thus established as A′B′ and so on to L′ and M′ connected, the curve will be a sine curve. That part from 0 to 180 deg. and above the horizontal line is of positive value, while that below the horizontal lines and extending from 180 to 360 deg. is of negative value.

In the sine curve shown in Fig. 52, the electromotive force rises from zero in a positive direction to 100 v., then again to zero after which it reverses its direction and again reaches a value of 100 v., but of negative value, followed by a return to zero. It will be noted that the highest point reached, or, in other words, the maximum electromotive force has a value of 100 v. That is, the maximum value is 100 v. and while this is given but little attention in ordinary practice, account must, however, be taken of it for the purpose of deducting formulas and the proportioning of insulation.

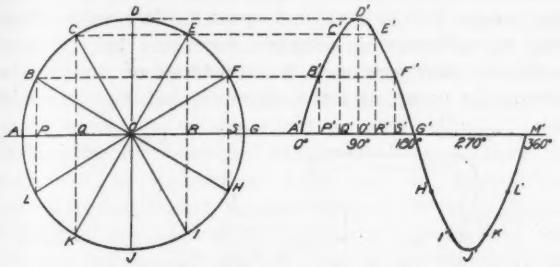


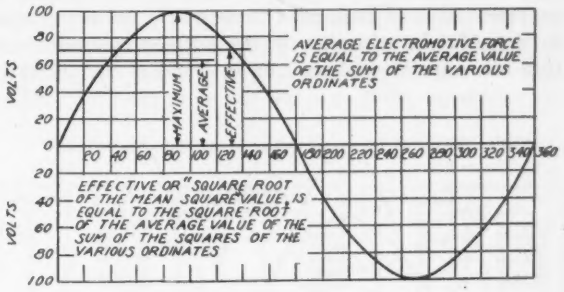
FIG. 51. SHOWING METHOD OF CONSTRUCTING THE SINE CURVE

Measuring the lengths of the ordinates erected at the various points along the horizontal base line, that is, in this particular case, at every 10 deg., and dividing the sum of these lengths by the number of points selected, we obtain the average length of the ordinates, which is in reality the average value of the electromotive force. By actual measurement of the ordinates of a sine curve, we obtain an average value of 0.637 of the maximum or in this particular instance, the average electromotive force would have a value of 0.637 times 100, or 63.7 v.

Electrical instruments do, however, not indicate the maximum value nor the average value, but the effective value of the electromotive force and current and it is therefore this which is dealt with the most. The effective value is in electrical engineering parlance frequently referred to as "the square root of the mean square" value and is obtained from a true sine curve by taking the square root of the mean value of the sum of the squares of the various ordinates. Its value is 0.707 of that of the maximum value, so that as in Fig. 52, where the maximum value is 100 v., the effective value is equal to 0.707 times 100, or 70.7 v.

INDUCTANCE

STRICTLY SPEAKING, there are two kinds of inductance, namely, mutual inductance and self inductance. As already explained in the early part of this series, a conductor carrying an electric current is surrounded by concentric lines of magnetic force which decrease in intensity with increase of distances from the center of the conductor. If a second "dead" conductor is within close proximity of a conductor carrying current, that is, sufficiently close to be within the magnetic field of the first conductor, the flow of electric current through the first conductor will have no effect upon the "dead" one. If, however, the strength of the current through the first conductor varies periodically, non-periodically, uniformly, or non-uniformly, the strength of the magnetic field will vary likewise and as a consequence due to such variation of magnetic field there will be induced within the second conductor an electromotive force, the values


VOLTS
MAXIMUM
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AVERAGE ELECTROMOTIVE FORCE IS EQUAL TO THE AVERAGE VALUE OF THE SUM OF THE VARIOUS ORDINATES
EFFECTIVE OR "SQUARE ROOT OF THE MEAN SQUARE VALUE" IS EQUAL TO THE SQUARE ROOT OF THE AVERAGE VALUE OF THE SUM OF THE SQUARES OF THE VARIOUS ORDINATES

FIG. 52. INDICATING MAXIMUM, AVERAGE AND EFFECTIVE VALUES OF ELECTROMOTIVE FORCE

and polarity of which are dependent upon the variation of the change of current strength within the first conductor and consequently upon the variation of strength of magnetic field surrounding this first conductor. If the current flow through the first conductor varies as a sine curve, the induced electromotive force values will also follow the path of a sine curve although the direction of the induced electromotive force at any instant is opposite to the direction of the electromotive force maintaining the flow of current through the first conductor.

This phenomena is termed mutual inductance.

On the other hand, let us assume having a coil of

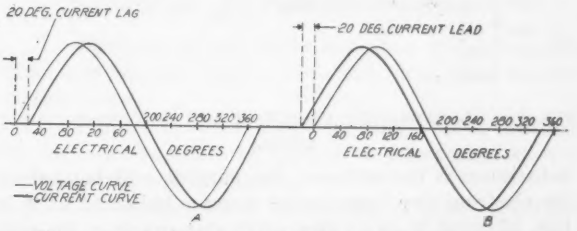


FIG. 53. ILLUSTRATING (A) LAGGING (B) LEADING CURRENTS

wire wound upon an iron core and carrying a current of electricity. Magnetic lines of force as previously explained will surround this so-called solenoid. Let us further assume, however, that the flow of current through this coil is suddenly stopped. As a result, the magnetic lines of force will break down, that is, the body of the flux will contract, and as the various turns of wire making up the coil lie in the path of these receding lines of force, an electromotive force termed the counter electromotive force, is induced within the conductors. This electromotive force, which also is opposite in direction to that of the induced electromotive force, is what is continuously being created within the wind-

ings of a coil of wire supplied with alternating current.

Mutual inductance is the name applied to this phenomena, the counter electromotive force of which is proportional to the rate of change of current provided the permeability of the medium around the conductor remains unchanged. The unit of inductance is the henry represented by the letter L and is that inductance existing when a uniform variation of current at the rate of 1 amp. per second produces a counter electromotive force of 1 v.

With only resistance included in a circuit supplied with alternating current, the current although of different unit value rises, falls and alternates in unison with the electromotive force and as a consequence the graphic representation of such conditions would be as indicated in Fig. 49. In other words, the current and electromotive force are in "phase" or in "step." If, however,

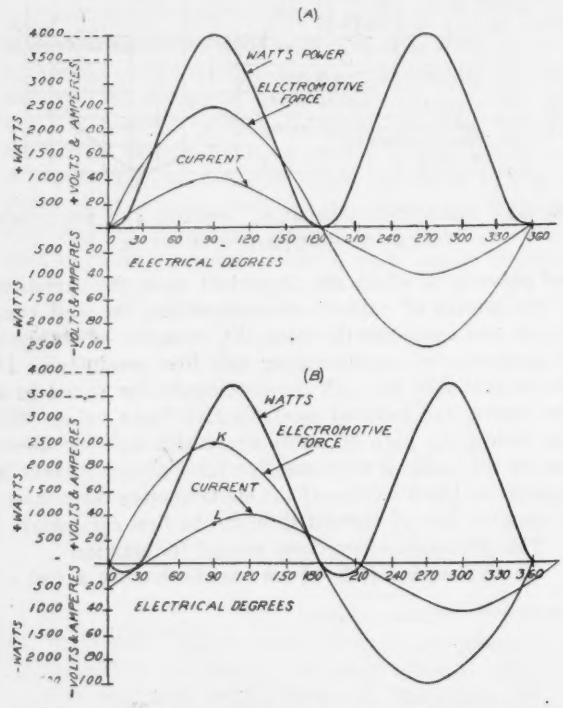


FIG. 54. ILLUSTRATING EFFECT OF LAG OF CURRENT UPON POWER

inductance is encountered, the current will lag behind the electromotive force in the manner indicated at A in Fig. 53; that is, as in this particular example, the electromotive force will have reached some appreciable value before the current starts from zero and likewise the maximum value of the electromotive force will have been reached before the current wave reaches its crest. This same difference in angularity, in this particular instance 20 deg., maintains as long as the value of the inductance remains unchanged; however, as the value of the inductance increases, the angular difference between the electromotive force and current waves increases until the angular difference is nearly 90 deg. Actually, however, a difference of 90 deg. cannot be reached. With little inductance there will be a like degree of lag; with considerable inductance the lag will tend to approach 90 deg.

Capacity

ANOTHER PHENOMENON of alternating currents is capacity, or capacitance, also sometimes termed permittance. This, the effects of which, as will be evident, are opposite to those of inductance, is the power of storing or holding an electric charge.

To understand more readily the nature of this property of alternating currents, let us refer to Fig. 55 where at A is shown a plunger pump P. each end of the cylinder of which is connected by piping to a chamber fitted with a diaphragm D D, while at B is illustrated a single-phase generator G the brushes of which, through the medium of the necessary connecting wires, tie in with the conducting plates C C insulated one from the other by means of a dielectric or insulator D D.

Assuming that the cylinder of the pump, the connecting pipes and the chamber containing the diaphragm are filled with water and that the piston of the pump is given an oscillating motion. Immediately the water is set in motion with the result that as the piston moves upward diaphragm DD is distended downward, while with a reverse motion of the piston, that is downward, diaphragm D D is distended upward. It is then evident that the alternating pressure generated by the pump must not only overcome the resistance of the pipe between the pump and the chamber, but a considerable

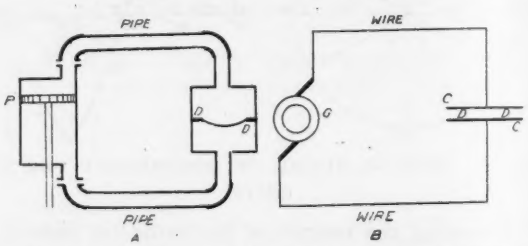


FIG. 55. ILLUSTRATING PHENOMENA OF CAPACITY

portion of such pressure must be employed in overcoming the inertia of the water in the pipe, first in establishing the current of water, and then stopping the current and starting it again in the opposite direction; and also to distend the diaphragm. In a like manner, the electromotive force generated by machine G must not only overcome the resistance of the connecting wires and the inductance of the circuit (which corresponds to the inertia referred to in the pump problem just citd), but it must also assist in producing an electrical stress which is created in the insulating material D D between plates C C as these are electrically charged first in one direction and then in the opposite direction. That is, due to the alternating values of the electromotive force, first the upper plate became positive and the lower negative, then the upper plate negative and the lower one positive. This arrangement of plate C C separated by the insulated medium of dielectric D D constitutes a condenser which permits an alternating current to surge back and forth but prevents the flow of a steady current in a like manner as diaphragm at A permits the surging of the current of water but prevents continuous flow.

The unit of capacity or capacitance is the farad and is the capacity or capacitance which a condenser pos-

sesses when one coulomb* of charge is drawn out of one plate and forced into the other by an electromotive force of 1v.

Where C is the electrostatic capacity of any condenser and E the electromotive force in volts, q, the charge drawn out of one condenser plate and forced into the other, is equal to the product of C and E.

With the introduction of capacity the effect is opposite to that due to the presence of inductance. Instead of lagging behind the electromotive force the current will tend, as indicated at B, Fig. 53, to lead the electromotive force.

Power Factor

As in the case of direct-current work, the power delivered by a single-phase alternating-current generator to a circuit or consuming device in which only resistance exists (no inductance or capacity present), is at any instant equal to the product of the number of volts and the number of amperes of current flow, so that as indicated at A in Fig. 54, the instantaneous values of power rise and fall from zero to maximum and back to zero again for each half current and electromotive force cycle. In this particular instance, the current and electromotive force reach maximum values of 40 amp. and 100 v. respectively and as a consequence and as indicated by the power curve, the maximum number of watts is equal to 40 times 100, or 4000. For all other instantaneous current and electromotive force values, the corresponding number of watts may be obtained by multiplication of such values and while the electromotive force and the current alternate through positive and negative values, the product, due to the fact that the instantaneous values are of like sign (positive or negative), is always positive. It is for this reason that no points in the power curve fall below the zero line.

Where, however, due to inductance or capacity, the electromotive force and current are out of phase, as where the current lags behind or leads the electromotive force, negative power values as shown at B, Fig. 54, are introduced. As indicated in this set of curves, the current lags 30 deg. behind the electromotive force, so that from zero to 30 deg. positive electromotive force values are multiplied by negative current values with the result that, as indicated, the corresponding values of power are negative in character. Beyond 30 deg., however, and up to 180 deg. all current and electromotive force values are positive and the corresponding power values positive. Another negative power loop occurs between 180 and 215 deg. after which, on account of all current and electromotive force values being of like sign (negative), the power curve is positive.

It is obvious, therefore, that where inductance or capacity exist P is not equal to E I where P is the power in watts, E the electromotive force in volts and I the currents in amperes. A factor known as the power factor and having a value depending upon the degree of lag or lead must be considered. Or, P is equal to E I cos. A where cos. A represents the cosine of the angle of lag or lead expressed as a decimal.

The values of the cosine of angles ranging from zero to 90 deg. are given in the table shown. The cosine of 30 deg. is, we find from the table, equal to 0.866, so that if the electromotive force has a value of 100 v. and the current 33 amp. the power in watts is equal to

$$P = E\ I \cos. A, \text{ or,}$$
$$P = 100 \times 33 \times 0.866$$
$$P = 2857.8 \text{ w.} = 2.8578 \text{ kw.}$$

and not = E I, or 100×33, or 3300 w., or 3.3 kw. as would be the case where the power factor is 1 (that is, where no inductance or capacity are encountered).

Let us assume having a generator which according to instruments is as above delivering 33 amp. of current while the voltage is 100, and the indicating wattmeter reads 2857 w. The product of the volt and ammeter readings is generally referred to as the apparent watts and the reading of the indicating wattmeter is the real watts. Dividing the latter by the former, that is, the real watts or 2857.8 by the apparent watts or 3300, we obtain as a quotient 0.866 the value of the power factor or, as it is more generally expressed, 86.6 per cent.

VALUES OF COSINE OF ANGLES FROM 0 TO 90 DEG.

Degrees	Cosine	Degrees	Cosine	Degrees	Cosine
1	0.99985	31	0.85717	61	0.48481
2	0.99939	32	0.84805	62	0.46947
3	0.99863	33	0.83867	63	0.45399
4	0.99756	34	0.82904	64	0.43837
5	0.99619	35	0.81915	65	0.42263
6	0.99452	36	0.80902	66	0.40674
7	0.99255	37	0.79863	67	0.39073
8	0.99027	38	0.78801	68	0.37461
9	0.98769	39	0.77715	69	0.35837
10	0.98481	40	0.76604	70	0.34203
11	0.98163	41	0.75471	71	0.32557
12	0.97815	42	0.74314	72	0.30902
13	0.97437	43	0.73135	73	0.29237
14	0.97030	44	0.71934	74	0.27564
15	0.96592	45	0.70711	75	0.25882
16	0.96126	46	0.69466	76	0.24192
17	0.95630	47	0.68200	77	0.22495
18	0.95106	48	0.66913	78	0.20791
19	0.94552	49	0.65606	79	0.19081
20	0.93969	50	0.64279	80	0.17365
21	0.93358	51	0.62932	81	0.15643
22	0.92718	52	0.61566	82	0.13917
23	0.92050	53	0.60181	83	0.12187
24	0.91354	54	0.58778	84	0.10453
25	0.90631	55	0.57358	85	0.08715
26	0.89879	56	0.55919	86	0.06976
27	0.89101	57	0.54464	87	0.05234
28	0.88295	58	0.52992	88	0.03490
29	0.87462	59	0.51504	89	0.01745
30	0.86603	60	0.50000	90	0.00000

Questions and Problems for Review

1. Construct a sine curve and show graphically the difference between single-, two- and three-phase electromotive forces.

2. Explain the meaning of the term "the square root of the mean square" as applied to alternating electromotive forces and currents.

3. A single-phase alternating-current generator operating at a voltage of 2300 is delivering 55.4 amp.; the indicating wattmeter reads 118,645 w. What is the value of the power factor?

The Director of Sales of the War Dept. announces that the Surplus Property Division of the office of Quartermaster General of Army is offering for sale by negotiation and at fixed prices a quantity of construction equipment, including steam engines, derricks, generator sets, gas engines, steam boilers and gas pumps, valued at approximately $900,000.

The U. S. Civil Service Commission announces that it is receiving applications to fill 150 positions of assistant instructor in motor transpart training schools. Entrance salaries range from $1800 to $2400 a year.

*The coulomb is an ampere-second; that is, the equivalent of the flow of 1 amp. for a period of 1 sec.

Electric Power Collection

A Proposition to Utilize Small Generators with Simple Switches and Fuses to Make Use of Our Small Water Powers and Thus Conserve Our Fuel Resources. By Charles P. Steinmetz

THE electric generator and the electric motor are identical. Often the same machine is used as generator or as motor, and where there are differences in construction, they are in details, to accentuate certain characteristics for certain purposes.

Thus, in a synchronous machine, we may add a squirrel cage winding in the field pole shoes, when used as a synchronous motor, to give a better starting torque, while we may omit this winding in the generator; but the turbo-alternator when left in circuit, with the steam cut off the turbine, continues to revolve and is just as good a synchronous motor; in a commutating machine we may add a series field when intended as a generator, to give better voltage regulation, and omit it in the use as a motor, since the speed regulation of the shunt motor is sufficiently close.

The average motor is installed with a switch to turn it on, and a fuse to cut it off in case of overload or accident, and then left to itself with practically no attention. In the generator installation, however, we find a very elaborate system of switchboards, instruments, controlling and protective devices, etc., requiring continuous and highly skilled attention. Why is this, if generator and motor are the same type of apparatus? Obviously, it is not due to the use of the machine, in the one case as motor, in the other case as generator, but it is due to the size of the machine. With the huge size of the average generator installation, an elaborate system of control and protection becomes necessary, which is not necessary with the average small motor installation, and indeed, in the installation of large motors, we find more controlling and protective devices than a switch and a fuse.

Thus, inherently a generator installation is no more complex than a motor installation. The complexity of the modern generator installation is the necessary result of its huge size, and a small generator installation could be as simple, limited to switch and fuse as controlling and protective devices, could be left to run itself with occasional inspection, as a small motor installation.

Thus, if the average size of generator installation has steadily increased, while the average size of motor has not, this is not due to the complexity required in the former, but the reverse is the case; the complexity of the generator installation is the result of its huge size.

The difference in the course of development of motor and generator thus must be found in other directions. As an instance, let us consider the application of the electric drive to the cotton mill industry, which is typical of the entire electric motor development.

When the first cotton mill was electrified in 1894, the steam engine was taken out, and a 400-hp. synchronous motor put into its place, driving by belts and shafts and countershafts the individual machines, that is, the power was generated electrically, but distributed mechanically. But in the new mill of the same plant, a number of 100-hp. induction motors were installed, each driving a line of shafting to which the individual machines were belted, that is, at least a part of the power distribution was done electrically. I need not to say that even this is antiquated and that experience has long proven that the most economical arrangement is to eliminate entirely mechanical power distribution and distribute all the power electrically, up to the individual driven machine. That is, to have individual motors at every machine. This has long become the standard method of electric motor application. This is the reason why the average size of electric motor is small, corresponding to the power required by the individual machine, and large motors are used only where a large unit of mechanical power is required, as at the rolls of a steel mill, or the propellor of the battle cruiser.

But in electric generation we are still in the first stage, that typified by the huge synchronous motor distributing power mechanically through numerous belts, shafts and countershafts. We collect the power of a watershed mechanically by elaborate hydraulic works, costing many times more than the most elaborate electric generating station, and then in a big unit convert the hydraulic, that is, mechanical power into electric power in a modern synchronous generating station. Or we burn millions of tons of coal under the steam boilers of our huge steam stations, extract 10 to 15, or possibly 20 per cent of its energy as electric power, and then pay for the condensing water to throw away the 80 odd remaining per cent of the heat energy of the fuel, while in numerous other furnaces we burn millions of tons of coal to produce heat, but waste the potential mechanical and electrical energy of this coal.

This is not a condition to make us proud of our industrial efficiency. But it came about naturally, as the result of historical development.

The first electrical development occurred where hydraulic power was available in concentrated form, at waterfalls such as Niagara, etc., that is, cases corresponding in motor development to the rolling mill or the ship's propeller. The synchronous machine is the proper type of generator for such installation, just as the synchronous motor is today, and always has been, the preferable type of motor for large units of power unless special conditions prevail and demand the induction motor, such as the need of frequent starting under heavy torque.

The same type of hydroelectric development was extended to conditions where water power was available in less concentrated form, and had to be collected by more extensive hydraulic works, gathering together the power of a watershed, and so the modern hydro-electric generating system was developed as the most perfect known method, within its scope and limits, of utilizing water power—mechanical collection of the water power by hydraulic works, and conversion to electric power in a big unit synchronous generating station.

But the high cost of the hydraulic work makes such development economically feasible only where large amounts of water power are available in fairly concentrated form, and with the increasing development of such power sites, the number of water power capable of

development by our present methods is decreasing, while most of the country's potential water powers cannot be developed by our present standard methods of hydro-electric generation, as the cost of the necessary hydraulic development, to collect the water power, is greater than the value of the power which may be collected. The only hope which can be seen for a more complete utilization of our country's hydraulic power, from the abandoned mill sites of New England to the mountain streams of the south and the west, thus lies in applying to the electric generation the same principles which have made the electric motor economically successful, that is, bringing the electric machine to the place of power. That is, just as we place individual motors at every machine where mechanical power is required, and distribute the power to them electrically, so do we place individual electric generators wherever along the water course hydraulic power is available, and collect the power of all these generators electrically.

For these relatively small individual generators, required for electric power collection, induction machines would naturally be used just as induction machines are exclusively used for smaller units of motors, however superior the synchronous motor is for larger powers.

Such a small induction generator station then would consist of a standard low voltage induction motor connected to some simple and cheap hydraulic turbine, a few hundred feet of pipe, and a low dam across the creek, to cover the intake of the pipe; a step-up transformer connecting the machine into a medium voltage collecting line, low tension switch and fuse to disconnect in case of accident. Hundreds of such small induction generating stations then would feed into the system over collecting lines, just as hundreds of induction motor installations receive power from it over distribution lines, and a large synchronous main station—steam turbine or hydraulic, or possibly even merely a synchronous motor station—would control the voltage and frequency of the system.

In similar manner, a simple and cheap turbine induction generator plant, interposed between the high pressure steam boiler and the steam heating system which it supplies, would abstract the small percentage of fuel energy which is available in conversion to mechanical and electrical power, and turn it into the electrical distribution system, on which the induction generator floats, thus collecting electrical energy from numerous small steam stations and eliminating the present wasteful use of coal.

Now this development of electric power collection is coming, as it is the natural economic development of electric generation, just as the individual motor drive was in electrical power distribution. There are already a number of such hydro-electric induction generator installations throughout the country, some in successful operation for years, and the field thus opened up is very large, larger possibly than all the electrical development which has taken place hitherto, and one of the features of this development is that no new type of apparatus requires to be developed, but the standard induction motor can be used as an induction generator, and has been used successfully for years in some plants.—General Electric Review.

The White Mazda 50-W. Lamp

THE first announcement of the successful development of the white Mazda lamp was made at the National Electric Light Association Convention at Atlantic City on May 21, 1919. This announcement was brief, for all the essential data had not at that time been standardized.

The outstanding characteristic of this lamp is the pleasing softness of its light. The large volume of light which the small filament emits is diffused to the point where the bulb itself appears luminous. The brightness

THE WHITE MAZDA 50-W. LAMP

of the bulb is about 13 candles per square inch over the brightest square inch of area, which is, of course, far below that of the filament of a Mazda B lamp. The white Mazda lamp is made in the 50-w. size, and, notwithstanding the low brightness of the bulb, supplies more light than the 50-w. Mazda B lamp.

There will, perhaps, be a tendency to use the white Mazda lamp without reflecting equipment because of the softness of its light. For most locations, however, the bulb is still too bright to be used alone; moreover, it must be remembered that reducing glare is only one of

TABLE 1. DATA ON LIGHT OUTPUT

Type of Unit	Output in Per Cent Of Bare Lamp Output	
	Mazda B	White Mazda
Glass Bowl, 6-inch Diameter.....	85.4	87.6
Glass Bowl, 7-inch Diameter.....	84.8	86.1
Enclosing Unit.....	77.5	76.4
Enameled-Steel Bowl.....	60.5	61.3

the functions of a reflector. From the standpoint of effective distribution of the light generated, it is just as important that a good reflector be used with a white Mazda lamp as with a Mazda C lamp.

Broadly, the field for the white Mazda lamp lies in the replacement of the smaller sizes of Mazda B lamps in existing reflector equipment. The effect produced by using white Mazda lamps in semi-indirect fixtures is particularly pleasing, for distinct shadows of the bowl edge and the bowl suspension, and all striations on the

ceiling, are eliminated because of the large area from which the light comes. For the same reason, white Mazda lamps are also particularly desirable for portable lamps, where their use will eliminate the formation of grotesque, and frequently annoying, shadows upon the walls or upon the pages of a book; fringe shadows, which are often very disagreeable, are eliminated.

In Table I are given the results of tests made to determine the effect of the diffusing bulb upon the output of lighting units. It will be noted that there is little difference in the absorption of any of the units tested when equipped respectively with Mazda B and with white Mazda lamps.

With regard to the service which may be expected from white Mazda lamps, it may be said that laboratory tests indicate a satisfactory degree of ruggedness for home lighting, office lighting, and hotel and public building lighting, where these lamps will probably find their chief application. The low bulb brightness may result in white Mazda lamps, despite their higher wattage, being used to replace many smaller lamps used on extension cords for the inspection of machined interiors and similar places difficult to light with any general lighting system, and only trials under service conditions can establish what degree of rough handling in drop-cord service the white Mazda lamp will withstand.

TABLE II. DATA ON WHITE MAZDA 50-W. LAMP

Size in Watts	Volts	Lumens	Lumens per Watt	Type of Bulb	Bulb Diam., Inches	Maximum Over-all Length, Inches	Base	Rated Average Life, Hours
50	110 to 125	490	9.8	Pear-Shape	2½	5-1/8	Med. Screw	1000

The white Mazda 50-w. lamp is made in the pear-shaped bulb, and it will be noted from the illustration that the bulb is tipless. The lamp has about the same maximum dimensions as the 40 and 50-w. Mazda B lamps; it is 2½ in. in diameter at the largest point, as compared with 2⅜ in. for the 40 and 50-w. Mazda B lamps. No difficulty should be experienced in replacing Mazda B lamps in existing reflectors or shades. Additional technical data are given in Table II.

ACCORDING TO delegates to the International Trade Conference now in this country the coal mines of Belgium were not damaged, as the invader meant to keep them, but they suffered abnormal wear and tear, particularly upon their hoisting cables, which have to be replaced. The output at the beginning of 1919 was 60 per cent of the pre-war total. It is now 84 per cent. The two causes which delayed the complete restoration of this industry, namely, insufficiency of transport and diminution of the productive capacity of the workmen, are gradually disappearing, and we feel that we can say that we shall soon reach the pre-war figures, as far as total output is concerned. Belgium is already able to export coal to her neighbors to the following quantities: 300,000 tons monthly to France; 50,000 to Italy; 10,000 to Holland; 50,000 to Switzerland, making a total of 390,000 tons, or 4,680,000 yearly. This assures to Belgium a yearly income of more than 200 millions of francs, a rather important factor toward the stabilization of the exchange.

Efficiency at the Switchboard

MAKING THE MOST OF SWITCHBOARD FACILITIES. BY JAMES T. KANE.

THE MANY ARTICLES and editorials recently published on the danger of reading carelessly or accepting too literally the indications of various switchboard instruments, particularly the synchroscope, recall to mind some observations of my own made during my power plant work.

DANGER OF INDECISION

ONE OF the most dangerous faults an operator can have, to my mind, is the habit of timidly synchronizing; that is, changing his mind after he has once started to close the switch. I was in a frequency-changer substation one Sunday afternoon while an operator was endeavoring to synchronize a unit. He had been on duty only a short time and had not bothered to change his clothes, when he discovered that the two running units were overloaded. He brought the third set to speed on the starting motor, and plugged in on his motor and generator synchroscopes. Since there was no speed adjustment possible between the motor and generator elements of any set nor between sets, it was necessary to close the motor switch when its synchroscope was at synchronism and the generator instrument was 25 degrees in advance of synchronism, in order that the generator would pick up its load; and this combination on the synchroscopes only repeated itself on every twelfth revolution of the lower frequency instrument.

The operator saw his combination and started to close the control button of the motor oil switch, then suddenly changed his mind. He took off his hat and coat, and made another such misplay. It was a warm day, and the perspiration streamed down his face. The Sunday afternoon railway load was jerky, and it had him worried. His collar and necktie next came off, twice more he lost courage when the control switch was about to make contact. He was in his undershirt and plainly exhausted when a helper whispered that the superintendent was coming. The next time the combination appeared, the operator closed the switch, and it was a perfect synchronizing shot. Such an operator would be wise in changing his occupation before he has wrecked his nervous system.

Switchboards are designed with the view of utility pre-eminent, and there are no devices installed that have no definite and essential purpose there; furthermore, the capable operator will be able to establish a definite relationship between the indications of every instrument on his board. No switchboard can properly be operated from only one instrument.

LET THE OPERATOR DO IT

IN THE 15,000-kw. central-station plant of a third-class city, almost 50 per cent of the early morning load consisted of street-lighting, both for the city itself and its suburbs. One night the operator came in "all tired out," and at daylight the engineer decided not to wake him up to take off the street-lighting load; instead himself went up on the switchboard and switched out all the mercury-rectifier arc sets and tub transformers car-

rying this load. He was so busy endeavoring to restore the generator voltage to normal, from which it had risen excessively, that he forgot that at that time every other morning he was busy throttling down the turbine speed because of the great reduction in load on the unit; nor did he think to look at the frequency meter, which would have shown him the cause of the high voltage. He had often "watched the voltage" for the operator, and the voltmeter was the only instrument with which he was familiar. When he did awaken the operator it was too late, for the turbine had overspeeded and shut itself down.

Power factor seems to be a deep mystery to many operators, who can not understand why with the same kilowatt load on their generators, the armature current at times is greatly in excess and the bus voltage considerably lower than at other times. They do not appreciate the value of the synchronous apparatus condenser plants, which may be utilized as synchronous condenser capacity; hence they do not take advantage of such apparatus by running it at a leading power factor and shifting over to it the wattless energy carried at a loss on their generators. In the same plant, I have seen one operator run two generators to maintain proper bus voltage; while another operator carried the same load on one unit, after having started up a few idle rotaries and run them as condensers with their fields over-excited and their direct-current switches open.

It all filters down to the one fact that to operate the switchboard efficiently, and through it to operate efficiently the whole plant, the operator must understand each of his instruments, their relationships to each other and be able to balance their indications one against the other and thus check the action of each. There is more science attached to switchboard operating than merely holding standard bus voltage.

Solder, Soldering Flux and Soldering

Solders and Fluxes Required for Soft and Hard Soldering of Various Metals. By F. A. Kartak

METALS to be united by soldering may be either the same or dissimilar, but the solder must be such as will alloy with both at the soldering temperature.

Two conditions must be fulfilled in all soldering work:

1. The surfaces to be united must be bright, smooth, and chemically clean.

2. Contact of air with the surfaces to be soldered must be excluded during the process, since this is likely to oxidize the surfaces at the soldering temperature.

These conditions are partly fulfilled by a mechanical cleaning of the surfaces, by filing, scraping, scouring or grinding, and further by the use of a so-called flux, which may assist in the cleaning as well as in preventing oxidation by excluding the air.

Solders may in general be classified as hard solders and soft solders, typical examples of which are given in Table I.

The hard solders melt only at the higher temperatures, and are usually employed for fine work where considerable mechanical strength of joint is required or where a joint of better electrical characteristics, as for fine instrument work is desired. The soft solders (or tin solders), those employed in the majority of soldering processes, are used principally because of the lower soldering temperature permitted which rarely exceeds 400 deg. F. At the lower temperatures it is not so difficult to prevent oxidation of the surfaces to be soldered.

Fluxes

The proper flux to be used will depend to a considerable extent upon the nature and material of the surfaces to be joined. A flux may act in one or more of the following manners:

1. As a means of covering the brightened metal surfaces to exclude air.

2. As a solvent for the metal oxides formed by the action of the air.

3. As a coagulant or detergent, cleansing and floating from the metal surfaces the oxides and other foreign matter present.

Rosin (or colophony) can be used alone only where the surfaces are bright and clean. Its principal use is in soldering iron covered with a coating of tin, where it is essential that a flux be used that will not, under any circumstances, eat through the tin coating. Rosin may be used only for soft soldering, since it chars at the higher temperatures.

The active constituents of the most commonly used fluxes may be classified as shown in Table II.

Zinc chloride, which forms the active constituent of practically all ordinary soldering fluxes, acts as a solvent for the metal oxides. It should contain no free acid, and is often neutralized by the use of ammonia. This is, however, a somewhat questionable procedure, since any free hydrochloric acid in the zinc chloride will react to form ammonium chloride, which may have a corrosive effect if not carefully washed from the finished joint. For this reason, when zinc or ammonium chlorides are used as fluxes, the finished joints should be washed to remove any excess of the chlorides, since both of them are corrosive.

Lactic acid or ammonium lactate has been found satisfactory for soldering zinc, copper and brass. It is particularly useful for soldering small zinc parts where zinc chloride is not satisfactory because of its peculiar action on zinc. When lactic acid or ammonium lactate are used on copper or brass, they will become tarnished in a few hours, because of the reaction with copper oxide that takes place at ordinary temperatures.

Ammonium phosphate in aqueous solution may be used on zinc, tin, copper and brass, but not on iron. When used in place of lactic acid, it will not tarnish copper or brass.

Hydrochloric acid is used in the soldering of galvanized iron or large zinc parts, where it reacts with the zinc to form zinc chlorides. To prevent future corrosion, great care must be taken to wash away the excess acid upon the completion of the joint.

Borax and boric acid are generally used as fluxes for hard soldering at high temperature, the dry crystals of borax fusing and forming a glass-like coating with the oxides, which are dissolved by virtue of the boric acid present.

Glass or sand, finely powdered, is often used in hard soldering, the oxides being dissolved by virtue of the silicic acid present.

Phosphoric acid, in a solution of alcohol, has been successfully used as a flux, the acid dissolving the metal oxides.

Ammonia, when used on brass, acts as a flux by reducing the oxides.

Soldering Fluids and Pastes

The so-called soldering fluids for ordinary work usually consist of a solution of zinc or ammonium chlorides to which has been added alcohol and glycerine in about the following proportions:

Saturated solution of zinc chloride..5 parts
Alcohol .....4 parts
Glycerine .....1 part

The alcohol aids in the cleansing of the metal surfaces, and the glycerine helps to give fluidity to the solution and adhesion to the joint when applied.

A similar flux is as follows:

Zinc chloride (neutral).....27 parts
Ammonium chloride .....11 parts
Water .....62 parts

Mueller's soldering fluid consists of:

Phosphoric acid solution.....1 part
80 per cent alcohol.....1 part

the compound being cast into sticks upon cooling. The disadvantage of using a stick in soldering is that the flux must be applied by melting it upon the heated metal of the joint to be made, thus encouraging oxidation before the flux can take action.

Rosin in powdered form may be applied directly to a tinned-iron joint in soft soldering. Borax used in hard soldering is usually applied in a dry or powdered state. Powdered glass or sand used in soldering iron at a red heat is applied in a dry state.

For soldering tinned iron, when it is not desirable to apply the rosin in powdered form, the rosin may be dissolved in alcohol, benzine, turpentine or sweet oil. The benzine and alcohol aid in cleansing the metal surfaces.

For work where the gummy residue left by the rosin-flux after soldering is objectionable, soldering-fats are often used, whose residues are greasy and may easily be wiped off. A good formula for this type of flux follows: For soldering tinplate, melt together 150 parts beef tallow, 250 parts rosin, and 150 parts olive oil. Add 50 parts of sal-ammoniac dissolved in as little water as possible. To give this a pasty consistence, reduce the amount of rosin.

In such pastes the sal-ammoniac may have a corrosive action if allowed to remain on the complete joint. For soldering iron, 50 parts olive oil and 50 parts powdered sal-ammoniac may be used. For soldering aluminum melt together 50 parts rosin and 50 parts tallow, and add 25 parts zinc chloride.

Soldering sticks are much the same as soldering fats or pastes with the addition of sufficient rosin to permit

TABLE I. CONTENTS OF TYPICAL SOLDERS AND THE FLUXES USED

No.	Name of Solder.	Composition in Parts.	Flux.	Melting Point.
1	Lead solder, coarse	Tin, 1; lead, 3	Rosin	797° F.
2	Lead solder, ordinary	Tin, 1; lead, 2	Rosin	439° F.
3	Lead solder, particularly good	Tin, 1; lead, 1	Rosin	388° F.
4	Tin solder	Tin, 1; lead, 1	Rosin, or zinc chlor. solution	334° F.
5	Tin solder, particularly good	Tin, 2; lead, 1	Rosin, or zinc chlor. solution	340° F.
6	Hard solder for copper, brass, iron	Copper, 2; zinc, 1	Borax	Above 797° F.
7	Hard solder for copper	Malleable brass, 5; zinc, 1	Borax	
8	Hard solder for copper, readily fusible	Copper, 1; zinc, 1	Borax	
9	Hard solder for copper	Hammered sheet-brass	Borax	
10	Silver solder for gold-workers	Silver, 19; copper, 1; brass, 1	Borax	
11	Silver solder for sheet	Silver, 2; brass, 1	Borax	
12	Silver solder for silver, copper, iron	Silver, 1; brass, 1	Borax	
13	Silver solder for steel	Silver, 19; copper, 1; brass, 1	Borax	
14	Silver solder readily fusible	Silver, 5; brass, 5; zinc, 5	Borax	
15	Gold solder	Gold, 12; silver, 2; copper, 4	Borax	
16	Bismuth solder	Lead, 4; tin, 4; bismuth, 1	Rosin, or zinc chlor. solution	320° F.
17	Bismuth solder	Lead, 3; tin, 3; bismuth, 1	Rosin, or zinc chlor. solution	311° F.
18	Bismuth solder	Lead, 2; tin, 1; bismuth, 1	Rosin, or zinc chlor. solution	291° F.
19	Bismuth solder	Lead, 2; tin, 1; bismuth, 2	Rosin, or zinc chlor. solution	232° F.
20	Bismuth solder	Lead, 3; tin, 5; bismuth, 3	Rosin, or zinc chlor. solution	201° F.
21	Tin solder	Lead, 4; tin, 3; bismuth, 1	Rosin, or zinc chlor. solution	

—Brant, Metal Alloys.

Soldering

After properly cleaning and clamping or holding together the metal surfaces to be joined and applying the flux, the joint may be heated either by the direct application of the flame of a blow torch, or by the application of a soldering "copper" or "iron," that has been previously heated. The use of the "copper" is advisable where there is danger of igniting other materials by the flame of the torch and when the solder has a low melting point. A blow torch, however, is necessary in hard soldering.

Whenever possible in soft soldering, additional mechanical strength should be given the joint by the use of a twisted-wire joint or a clamped seam in sheet-metal, the solder serving principally as a locking or sealing medium. In hard soldering or brazing work, the solder is mechanically strong enough to withstand such strains as the metals may be subjected to.

In using soldering "coppers," the life of the copper is greatly shortened if it is allowed to overheat in the

flame of the blow-torch or in the furnace, causing excessive oxidation and consequent scaling. If it is badly overheated, it may be necessary to file off the oxide and smooth the point, after which the point or tip should be retinned, heating the copper to its proper temperature, and coating with solder, by rubbing it on the solder after cleaning with soldering flux, or, preferably, with ammonium chloride.

TABLE II. PRINCIPAL CONSTITUENTS OF SOLDERING FLUXES

Name of Material.	Principal Fluxing Action.	Principal Use.
Rosin (colophony) ..	Detergent	Tinned iron, copper, brass
Zinc chloride	Oxide solvent....	Copper, brass, tin, iron
Ammonia	Reducing agent	Brass
Ammonium chloride	Oxide solvent ..	Copper, brass, tin, iron
Hydrochloric acid ..	Formation of zinc chloride	Zinc, galvanised iron
Ammonium phosphate	Oxide solvent ..	Zinc, tin, copper, brass
Lactic acid or ammonium lactate	Oxide solvent ..	Zinc, copper, brass
Phosphoric acid	Oxide solvent ..	Copper, brass, bronze
Borax or boric acid	Oxide solvent ..	Copper, brass, silver, gold
Powdered glass, or sand	Oxide solvent ..	Iron

In hard soldering, it is preferable to clamp the two edges or metal parts in proper relationship, place the borax-flux upon the joint, heat with a blowpipe or torch, and when the joint is sufficiently hot apply the solder.

The spreading of solder upon a brass or copper surface may be prevented by painting the surface around the soldering-zone with a weak solution of water-glass, over which the solder will not flow.

In soldering cables or wires into lugs, it is first necessary to tin the recess in the lug as well as the end of the cable by heating and applying flux and solder. By applying heat to the lug and partly filling it with solder,

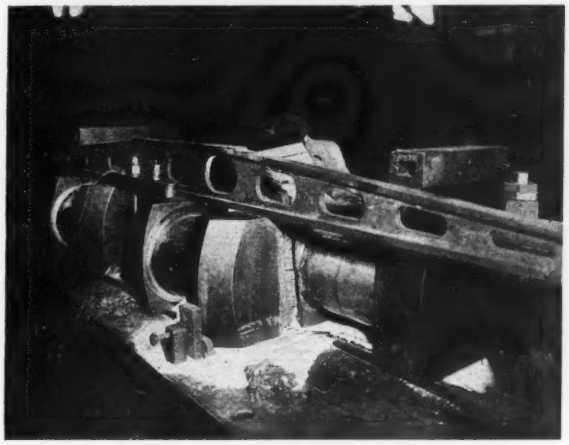


FIG. 1. CRANK SHAFT LINED UP ON TABLE READY FOR WELDING

the process may be completed by plugging the tinned cable-end into the lug and cooling it while holding it in position. If too much solder is used, it will overflow and adhere to the outside of the lug unless this be first covered with a coating of light oil of high flash-point.

The soldering of aluminum has always been attended with difficulty for the reason that metallic aluminum oxidizes almost instantly upon exposure to air. The difficulty has, therefore, been to obtain a satisfactory metallic contact between the solder and the aluminum. A satisfactory manner of soldering is by first cleaning the aluminum surfaces thoroughly of grease and dirt with benzine. The following solder is then applied with a "copper":

Block tin	28	parts
Phosphor tin (10 per cent phosphorus)	14	parts
Lead	..... 3½	parts
Spelter	 7	parts

After the molten solder has covered the surface, it should be scratched through with a wire brush to break the oxide on the metal surface. Quick manipulation is necessary.

FIG. 2. THE COMPLETED WELD

The soldering of cast iron is a difficult process because it is hard to obtain a uniformly adhering soldering-surface. A smooth cast-iron surface contains numerous small particles of carbon which interfere with a satisfactory joint. To clean cast-iron surfaces for soldering, especially in corners or openings which it is difficult to scrape or brighten mechanically, a thorough acid pickling followed by a lavish treatment with strong soapsuds will be found satisfactory in many cases.—Wisconsin Engineer.

An Unusual Welding Repair Job

AN unusual welding repair job, which required high engineering ability and skill to handle successfully, was that of a broken 6-ft. crank shaft, which was broken through the web, as shown by Fig. 1.

This shaft was part of the equipment of the Houston Ice & Brewing Co., Houston, Texas., but as repairs could not be made in that section the broken shaft was shipped to Jersey City, N. J., where it was repaired by electric welding.

The greatest difficulty was insuring proper alinement of the shaft at the conclusion of the work. The shaft was clamped to the table, and lined up as shown in Fig. 1, and the welding proceeded after the metal at the break had been chipped out to insure a clean surface for the added welding metal to fuse with.

The job as finished is shown in Fig. 2; when the welding was finished, the shaft was tested in a large lathe and found to be entirely true from end to end.

The Hetch Hetchy Water Power Project

TEMPORARY HYDROELECTRIC PLANT USED IN CONSTRUCTION. METHOD OF LIGHTING TUNNEL. WATER SUPPLY

SAN FRANCISCO'S great Hetch Hetchy power and water project is to be constructed exclusively with electrically operated equipment. For the purpose of generating the necessary current a temporary hydroelectric power plant has been constructed at Early Intake. This plant, referred to as the Lower Cherry River power development, will generate all of the electric power required for construction purposes for the entire project, from the main Hetch Hetchy dam to Moccasin Creek.

The water wheels are Francis turbines operating at 720 r.p.m. under a maximum head of 346.5 ft. including a draft head of 15 ft. These turbines are direct connected to 2300-v., 3-phase, 60 cycle generators, with direct connected exciters. The voltage is stepped up through a single bank of transformers to 22,000 v. for transmission to the various substations located along the 19 mi. of aqueduct to the west and at the main Hetch Hetchy dam site 11 mi. to the east of the temporary power plant.

The interior of the power plant is shown in Fig. 1. The power transmission lines are shown in Fig. 2; Fig. 3 shows the outdoor transformers at Big Creek shaft. Here are also located the electric motors for operating the elevator at this shaft. One of the compressor plants, of which there are four, all identical in capacity and type, is located here. These four plants each consist of a two-stage compressor equipped with short belt and idler drive, and driven by a 100-hp. squirrel cage induction motor. Figure 4 shows the face of Priest Tunnel. This shows a specially constructed device for carrying electric lights for lighting the tunnel during construction. This device consists of a circular board about 12 in. in diameter, to which electric lights connected to reinforced lamp cord about 100 ft. long are fastened. A wire guard is also fastened to the circular board and protects the bulbs from being broken from flying pieces of rock. In the bottom of the circular piece of wood there is a hook, which enables the device to be hung on the side of the wall as shown in the photo. When a charge of dynamite is about to be exploded, the lamp is laid on the floor of the tunnel, and the last man to leave the heading picks up the lamp and carries it back with him, a safe distance, until the charge is exploded, when it is carried back to the face of the tunnel and work proceeds again.

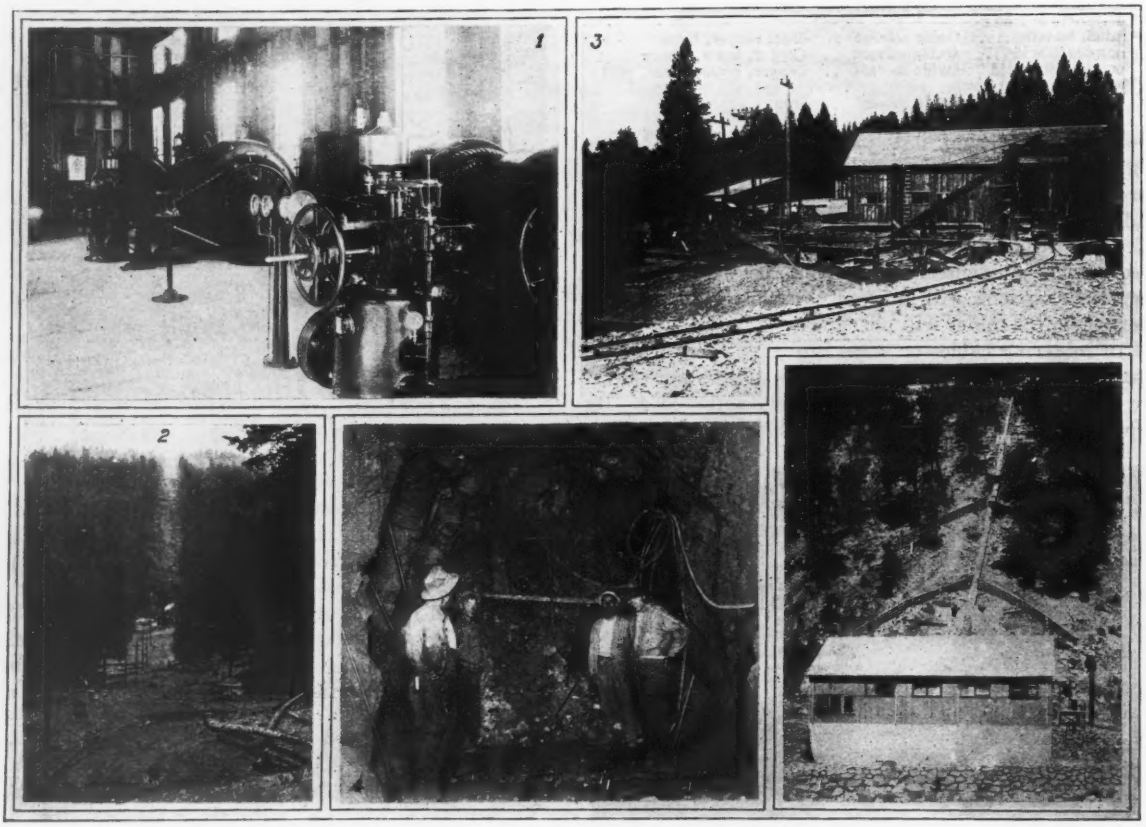


FIG. 1. INTERIOR OF TEMPORARY POWER PLANT
FIG. 2. TRANSMISSION LINE
FIG. 3. LOCATION OF OUTDOOR TRANSFORMERS, ELEVATOR SHAFT AND AIR COMPRESSOR
FIG. 4. METHOD OF LIGHTING THE TUNNEL DURING CONSTRUCTION
FIG. 5. EXTERIOR OF TEMPORARY POWER HOUSE

The use of electrically operated machinery in the construction of the project will both effect a great saving and increase the efficiency of the men.

Water Supply

Water for the operation of the power plant is diverted from Cherry Creek into a conduit of 200 sec.-ft. capacity 3.3 mi. long. The pressure pipe line connecting the water wheels with the forebay at the lower end of the ditch comprises 530 ft. of 42-in. pipe.

To insure sufficient water for operating purposes during the dry season, a temporary dam was built at Lake Eleanor which will raise the water level of that lake about 30 ft. Water released through the gates of Eleanor dam will pass down the channel of Eleanor Creek to its confluence with Cherry Creek, thence flowing in the channel of the latter stream to the diversion works, whence it will pass into the conduit leading to the temporary power plant.

News From Washington

Sale of War Material, Power Plants, Automobiles and Metals
Merchant Marine Status. By A. P. Connor, Special Correspondent

Congress is in somewhat of a mix-up, and has practically dropped the development of the water powers of the country, so that this will become the opportunity of other sessions.

Unfortunately the sale of war material is not proceeding as smoothly as could be desired, and apparently with but little practical value to the people in general. Publicity is given to the fact that war material is for sale, but disappointments and long, exasperating waits are in order for those who seek the "bargains." In Washington conditions are perhaps worse than any other place. For instance, sales are advertised, but on arrival would-be purchasers are turned away because there are no such goods as advertised. The people buying are kept several hours in line, and after going through the necessary red tape and frequently given the wrong goods, and with little prospect of having them righted. The goods being sold, contrary to general opinion, are not goods that were subjected to army specifications, but goods taken from the commercial storages, just as they were, and accumulated for the needs of the soldiers regardless of the ordinary specifications. The material that was bought under strict specifications will not be sold at present.

In the case of machinery, there is a possibility of a large buyer being outfitted with comparative quickness. Thus, if a factory burns down and needs new equipment to supplant the old destroyed and at the earliest possible moment to get the factory working again, it is understood that the War Department will immediately provide the facilities to assist that manufacturer immediately, and get the material on its way. The manner of charging for the material is interesting and is based on a definite curve, which is shown herewith, depending on the use the machine has been put to in time and work. Thus, the buyer can obtain the machine knowing that he will pay what it is reasonably worth and not according to an indefinite estimate.

Power plant material will be sold according to conditions in the district in which it is located. If a power plant is dismantled, the apparatus will be sold according to a system based on that used for machinery. It is expected, however, that the material will be sold to the factories or interest adjacent to the plants; in most cases, these plants are in connection with extensions to existing plants, and will be easier to leave with the factories, etc., to which they are attached.

Automobiles, for some unknown reason, are being held back and information provided very meagerly about them. In Baltimore there are thousands of machines in all types and forms, many of which have never been uncrated, and others which are rusting in the fields. Still the question of selling them has apparently not reached definite form, although there is perhaps a greater demand for this material than any other.

The manner in which metals are being sold has received considerable criticism among manufacturers because there is no definite manner of knowing what the Department will do next. Parties who obtained prospective buyers have been compelled to stand the trouble for their efforts and lose personal customers because between the time of negotiations with the Department

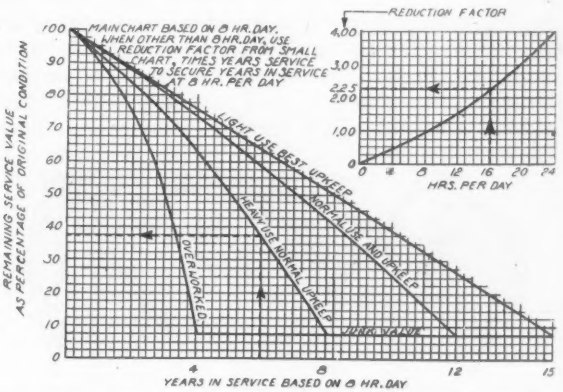

REDUCTION FACTOR
MAIN CHART BASED ON 8 HR. DAY.
WHEN OTHER THAN 8 HR. DAY, USE
REDUCTION FACTOR FROM SMALL
CHART, TIMES YEARS SERVICE
TO SECURE YEARS IN SERVICE
AT 8 HR. PER DAY
HRS. PER DAY
LIGHT USE, BEST UPKEEP
NORMAL USE AND UPKEEP
HEAVY USE, NORMAL UPKEEP
OVERWORKED
REMAINING SERVICE VALUE
AS PERCENTAGE OF ORIGINAL CONDITION
YEARS IN SERVICE BASED ON 8 HR. DAY

CHART FOR USE IN APPRAISAL OF STANDARD MACHINE TOOLS TO DETERMINE SERVICE VALUE

and the actual buying of the material the latter have changed the prices. The prices are based on the fluctuations of the market and there is practically little inducement to buy from the Government; but, in fact, the people are left practically in the hands of the metal controllers. Whether this is the proper policy or not is difficult to determine.

Treasury Power Plant

The treasury power plant that was objected to nationally several years ago, but whose construction was, nevertheless, continued for a time, was for some departmental reasons quietly stopped and arrangements were made with the contractors to settle the contract without the work being completed. There is, therefore, little

prospect now of the chimneys of this power plant defacing the sky line of the parks about the Washington monument.

The prospects of the United States having a Merchant Marine compatible with the dignity of this nation, appears to be less bright every day. The Shipping Board is passing the matter to Congress and Congress is not taking any initiative. There is good reason to believe that the Shipping Board is looking at its position from a strictly war-time view, and without any special regard for the requirements of peace in the matter of ships, regardless that the need of them exists and regardless of the extent their construction would promote the industry of the country. In this policy it may be legally correct, but the writer sees a great loss in the way of revenue business, industry and prestige for the United States if it neglects this opportunity to become the leading ship manufacturer and user of the world, although, of course, it may reduce the necessity for a large Navy. Hog Island has turned out about 57 ships in a little over a year, these ships being 7500 and 8000 tons in size and of steel. The future of this shipyard is uncertain, especially until a definite upbuilding or suspension of shipbuilding is pursued by the Government or the Shipping Board.

While there is a turmoil in the industrial field, there is nothing to fear for the future of this country. Labor feels better during these days because it is much better paid on an average than in the past; and while there is still agitation for more wages, it is more because of the desire to get more than living conditions actually require, for in spite of the high cost of living everybody is working and able to live fairly comfortably, and much more so than before the war, when conditions in industrial lines were more or less desperate. The coming year seems likely to be one of the greatest years this country has ever known or ever will know, and there need be no fear of lack of work for all.

Industrial Safety---IV

EYE PROTECTION AND SAFE CLOTHING. BY FRED W. ROSSELAND

EYE injuries were—and are still—very common in many kinds of work and their prevention was one of the first efforts of the Accident Preventionist. The first eye protectors were ordinary spectacles, but these were soon found to be inadequate. Then came spectacles equipped with side shields, and, later, improvements increasing the size and strength of the lens, strengthening the frame, shaping the side shields to the contour of the face, making the temples more comfortable, etc. As a result, we now have goggles which can be made to fit with a fair degree of comfort any human face and which protect the eyes from flying objects, from the minute dust particles to the larger, heavier objects such as chips of steel or rivet heads. Lenses can be secured which, except under extraordinary circumstances, will not fly into the eye if broken. Goggles may be secured for protection against acid splashes, fumes, and gases, provided with lenses which if broken will still protect the eyes from injury.

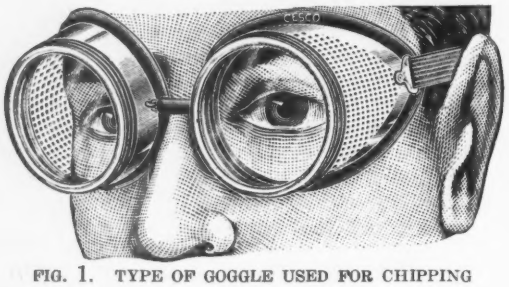


FIG. 1. TYPE OF GOGGLE USED FOR CHIPPING

When enforcing the use of goggles, judgment must be exercised, for they are not necessary for every operation. In some operations, in fact, other forms of protection are equally safe; for example, the glass shield for grinding wheels, for tools at lathes, milling machines, etc.; the use of screens; and changes in methods of operation.

Judgment must be used in selecting goggles to be worn by workers. Usage divides goggles into three general classes: (1) to protect from injurious light and heat rays, (2) to protect from acid fumes and gases, and (3) to protect from flying objects. These goggles are not interchangeable.

EYE PROTECTION FROM LIGHT AND HEAT RAYS

SAFETY GOGGLES to protect from injurious light and heat rays vary from the lightly tinted goggles worn to protect from the sun's rays or their reflection, to the almost opaque lenses used to protect the eyes from injurious light and heat rays developed in electric welding. The lenses are not suitable for protection against flying chips or for grinding.

EYE PROTECTION FROM FUMES AND GASES

SAFETY goggles to protect from acid fumes and gases are not required to resist blows, and the lens may be simply clear glass. In this form of protection the goggle frame must be of a material which will not be corroded by acid fumes or gases, shaped to the contour of the face, and air-tight. These goggles are unsuitable for any purpose other than those for which they are designed.

EYE PROTECTION FROM FLYING PARTICLES

GOGGLES to protect from flying particles vary from the lightweight wind-and-dust goggles to the strong, heavy chipper's goggles. Here again judgment must be exercised, for the wind-and-dust goggles do not provide sufficient protection for chippers and the chipper's goggle may be too heavy and uncomfortable for workers who are not chipping.

We shall not go into detail as to methods of testing. The Council's Safe Practices pamphlet entitled "Goggles" contains much information on this subject.

/ Abstract of lecture delivered before the Schools for Safety Engineers.

Clothing

Formerly workers wore any clothing that they wished to, usually the poorest suit of clothes and the poorest shoes that they owned. No particular attention was paid to shoes or to head covering. It was soon discovered that clothing had a great deal to do with accidents and it has been proved that, in certain lines of work at least, proper shoes, proper working garments and head covering definitely reduce the accident hazard.

Aside from special types of shoes men and women workers should wear shoes with low, broad heels and stout soles. In some industries a metal soled shoe is giving satisfaction, giving protection against practically every kind of sharp edges, projecting nails, etc., and against burns. Rubber shoes for linemen are on the market and are reported to be giving satisfaction.

The combination, formerly very common, of overall and jumper protects the clothes, but the one-piece garment is much superior. This garment should fit reasonably snugly, particularly about the neck, wrist, and ankles. Such a garment has few flaps and loose ends likely to catch in moving machinery. This garment

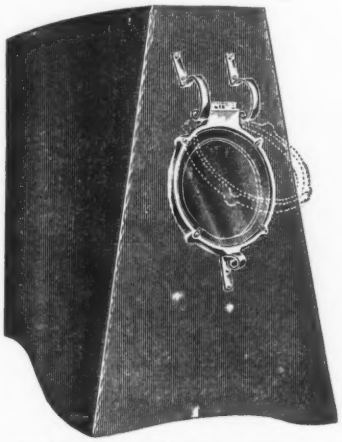


FIG. 2. AN APPPROVED TYPE OF ARC WELD HELMET, WHICH RESTS ON THE SHOULDERS

should be worn by practically every factory worker, and, in fact, by every one doing work in which it is necessary to protect the clothes. Women workers will find the one-piece garment satisfactory. In probably the majority of operations carried on by women the trousers may safely be replaced by a rather short close-fitting skirt. However, in every occupation around operating machinery or that requires climbing, they will find that trousers are a decided convenience and decrease the liability of injury.

Many injuries have resulted from the lack of or improper hand protection. Injuries due to lack of gloves occur in the handling of material and may be caused by sharp edges or by hot substances. The types of gloves worn vary from "hand leathers" which protect only the palm, to mittens and leather gloves. In every case the hand covering should fit loosely, so that it may be easily removed should the glove become caught in any way. Leather gloves, reinforced with strips of thin steel ribbon or closely studded with steel rivets, wear well and give excellent protection.

The more serious injuries have resulted when gloves became caught in a moving machine part and drew the hand into the machine. Except where gloves are absolutely necessary because of weather conditions, employes operating machines should not be permitted to wear them; and then the gloves should be hard finished so that they will not readily catch in moving parts, and should fit very loosely, so that if they do catch they can be quickly removed. Gloves for the electrician must provide protection from electricity as well as from the other hazards. The only protection against electricity for the hands is the rubber glove. Rubber gloves, however, which have been punctured by pin pricks, in worn

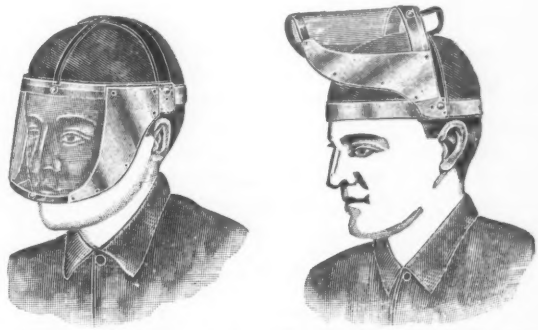


FIG. 3. FACE SHIELD OF NON-INFLAMMABLE MATERIAL SUITABLE FOR USE BY THE FIREMAN

spots or in some other manner, are valueless as insulation. Rubber gloves must be frequently tested and carefully stored, for the rubber deteriorates rapidly under certain conditions.

Helmets and Respirators

Helmets are necessary for sand blasters and for electric welders. In some plants sand blasting is done in cabinets, thus eliminating necessity for a helmet, and some kinds of electric welders are so encased that a helmet is unnecessary. Respirators are necessary in several operations and there are a number of types on the market. Breathing apparatus, often equipped with oxygen supply, is more and more commonly used and is giving satisfaction. Respirators are probably the most difficult problem, for they are uncomfortable and workers object to wearing them, and it may be necessary to educate employes to the necessity for them.

St. Louis Globe-Democrat states that a movement has been launched at meeting of coal operators and representatives of civic and commercial bodies in St. Louis to make American Mining Congress, which will be held in St. Louis from Nov. 17 to 21, greatest industrial convention ever held in the United States.

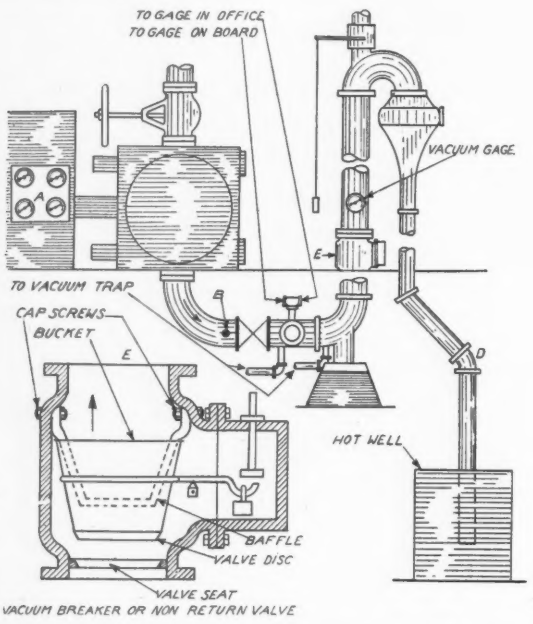
An engineer went to work one night "feeling bad." "Shucks!" he murmured; "Jim Coleman is my head fireman tonight, and Jim has never failed me yet!"

So he stretched himself out comfortably and went to sleep. But Mrs. Coleman had been sick for some days, and Jim had got no rest. At three o'clock in the morning, the engine got a bad dose of water, wrecked itself, and killed the oiler.

Overcoming Loss of Vacuum

THE ILLUSTRATIONS show the manner in which one of our engines, a 2500 hp. compound, is piped to the condenser.

One morning during normal operation the vacuum on the gage board in the engine room dropped suddenly from 28 to 18 in. accompanied by the sound of the exhaust being withdrawn. Another gage some 10 ft. farther along on the main exhaust pipe showed 28.5 in. Both gages were at once removed and tested out in connection with the mercury column and found to be substantially correct.



SHOWING LOCATION OF VACUUM GAGES, AND THE SEAT OF THE TROUBLE

In the meantime, the steam consumption increased so that another 250 hp. boiler had to be cut into the line.

During the noon shut-down, a hole was drilled and tapped for a 0.25-in. pipe, as shown at B, and a vacuum gage connected. On starting up, it was found that gage at B corresponded with that on the gage board.

The joints and all bolts on the entire exhaust line from the low-pressure cylinder exhaust nozzle to the relief valve on the roof was carefully gone over with a candle for leaks; none were found.

At 5 p. m. a blank flange was bolted to the 45 deg. ell at D, and the entire exhaust line put under steam pressure of 30 lb., but still no leaks were found.

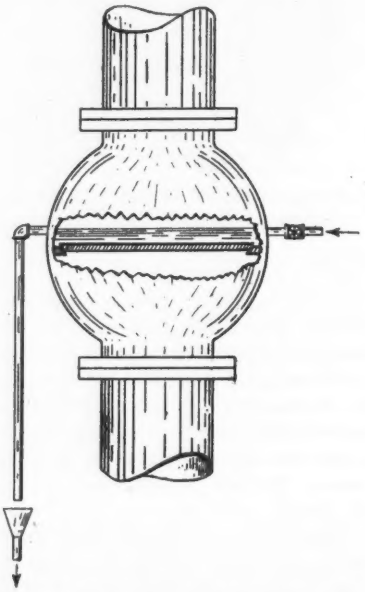
The vacuum breaking or non-return valve E, had a flange which gave access to the interior. This was removed to permit examination, which revealed that one of the capscrews that held the strap holding baffle in position had come out. This allowed the movement of the bucket to bend the strap, hence limiting the upward travel of the bucket and restricting the opening around the valve seat and bucket, causing the exhaust to be wiredrawn.

Replacement of the lost capscrew tightening the other two, after tapping the bolts through the valve beds, the application of a liberal supply of red lead, beading the ends over, and replacing the flange bolts, completed the job.

On starting up, the vacuum maintained as shown by the three gages referred to was 28 in. RECEIVER.

Water Seal for Atmospheric Relief Valve

WHERE an atmospheric relief valve is installed on the condenser or turbine exhaust line, it is highly essential that no air leak into the vacuum system through the valve seat, or a serious impairment of the vacuum will



CONNECTIONS FOR SEALING ATMOSPHERIC RELIEF VALVE WITH WATER

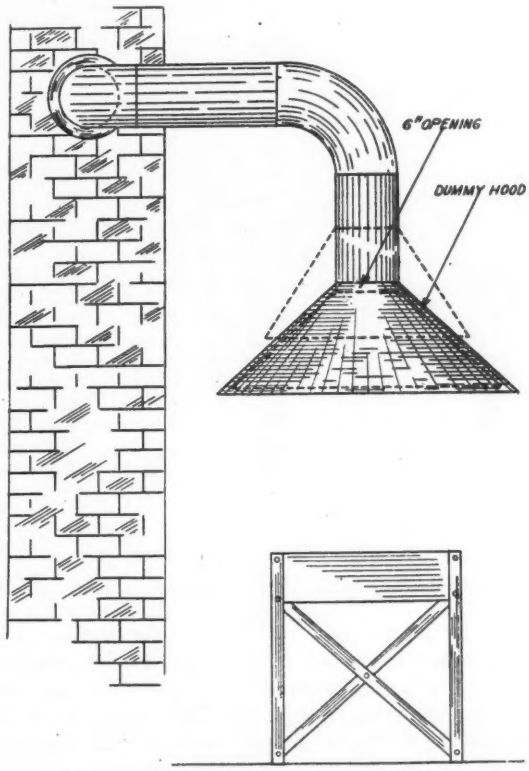
be the result. The method usually employed to prevent this is to "water-seal" the seats of the valve so that no air can be drawn—a slight admission of water being, of course, preferable to the entrance of air.

Because of the possibility of some water leaking past the valve seats, it is necessary to supply water instantly,

and this can be done as shown in the sketch. The water seal above the valve seat, as shown, is maintained by adjusting the water inlet control valve, this valve being opened just enough to flow a very small stream of water across the valve seat. The overflow is taken off the opposite side and the overflow pipe is broken at a convenient point with a funnel discharge as shown, so that the flow of water through the overflow can be observed. The inlet valve is adjusted so that this will be a very fine stream, about one-half the diameter of a lead pencil. If the operator notices this stream flowing, it is a sign that everything is OK. If no water, or very little, is noted flowing, it is an indication that some water is leaking through the valve seat, and the valve should have attention.

Curing a Smoky Forge

SMOKE which should have been carried out through the hood over one of our blacksmith forges, for some reason or other seemed to persist in finding its way to the outer edge of the hood and from there would pass into the shop. This, as may be expected, was a nuisance which had to be done away with.



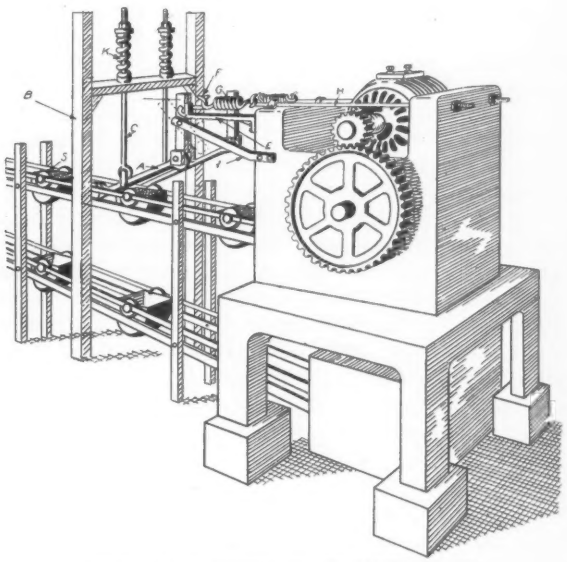
SHOWING ARRANGEMENT OF DUMMY HOOD

Accordingly, I changed the upper part of the hood as shown by the dotted line in the accompanying sketch and placed within it what may be called a dummy hood having a 6-in. outlet at the top, but with an over-all diameter somewhat less than that of the actual hood. With this arrangement part of the smoke passed through the 6-in. opening, but that which did not would creep to the edge of the dummy hood and, once it reached this point, it would immediately curl around the edge and find its way between the dummy hood and the real hood and out through the stack. E. C. FISCHER.

Safety Stop for Bucket Conveyors

POWER PLANTS using bucket conveyors driven by electric motors will find in the accompanying illustrations a satisfactory protection against service interruption due to the sudden stoppage of the motor when the current is cut off and the buckets loaded. This condition causes the train of buckets to go backward slowly at first, but increasing in speed at a dangerous rate.

It will be seen in the illustration that when the buckets are moving in the forward direction, the wheels raise the brake arm A automatically and allow it to fall as soon as the wheel has passed the end of the arm. This drop of the arm is controlled by rod C and spring K, and should be so adjusted as to clear the rail about ½-in.



GENERAL ARRANGEMENT OF SAFETY STOP

The working principle is as follows: When the conveyor is stopped with the buckets loaded and the train of buckets starts moving backwards, one of the wheels S, will engage the curved portion of the brake arm, A, spring it backwards, and moving the main lever arm into the position shown dotted. This causes the weight of the loaded buckets to be thrown on the spring G and the rod H, thus stopping the conveyor.

OTTO DORTHEN.

Deadly Work of Flywheel

THE ARTICLE published on page 804 of the Sept. 15 issue of Power Plant Engineering has afforded me much interest. Theoretically speaking it seems conclusive that the accident was caused in a manner described from belt trouble. G. H. Wallace is correct in his statements if the accident was really caused from what he supposes; but as there is nobody to answer his suppositions, we can only place it in a category of probable causes.

First we have a 16 by 42-in. engine operating under

a pressure of 125 lb. at a speed of 90 r.p.m., equipped with a flywheel having a diameter of 14 ft. and a 26-in. face. An engine of this size should not make over 78 r.p.m. and the flywheel diameter should have been 12 ft. with a 23-in. face instead of 14 ft. with a 26-in. face weighing 8 tons. The weight of the wheel should have been 12,300 lb.; therefore we have an oversized flywheel. No doubt if the dead engineer were alive he would state that that occurrence had happened quite a number of times before, but he had always been able to get to her in time, but this time he failed.

I differ with G. H. Wallace in his opinion that the belt trouble caused the accident. Chances are that, even if the belt had broken and rolled, throwing additional load upon the engine, causing the governor to admit more steam, as soon as the strain was released the governor did not have time to cut the steam down before the wheel went to pieces. I am sure that any halfway working governor would have taken care of any irregularity of that nature.

Regardless of all care and attention that experience and scientific knowledge can give us, these accidents will occur, because the diameters of the pulleys are too small for the load they have to pull, owing to the fact that the face portion of, for instance, 10 and 12-in. pulleys, with which the belt comes in contact, is not near so great as that with which a belt will come in contact on an 18, 20 or 24-in. pulley.

An engine operating under the condition of small pulleys for the governor belt has to be watched very carefully. You may take a first-class belt operating upon small pulleys, and if you will observe, you will note that for almost no cause an engine will pick up speed all at once, and if the operator is not alert and right on his job trouble will occur.

There is absolutely but one remedy for these dangerously small pulleys, and that is to make a cross drive out of your belt by reversing the motion of your governor, by doing which you greatly increase the face of the belt upon the pulley. An extremely tight belt will make good at the job for an uncertain length of time, and belt dressing will also assist in eliminating this annoyance temporarily. But do not use belt dressings upon your governor belts, for even a drop or two of oil from some source at intervals, unnoticed by the operator, falling upon the belt will produce the same effects.

In surmising all of the probable causes of this accident, I would attribute it to a slipping governor belt, as from that the majority of these accidents occur.

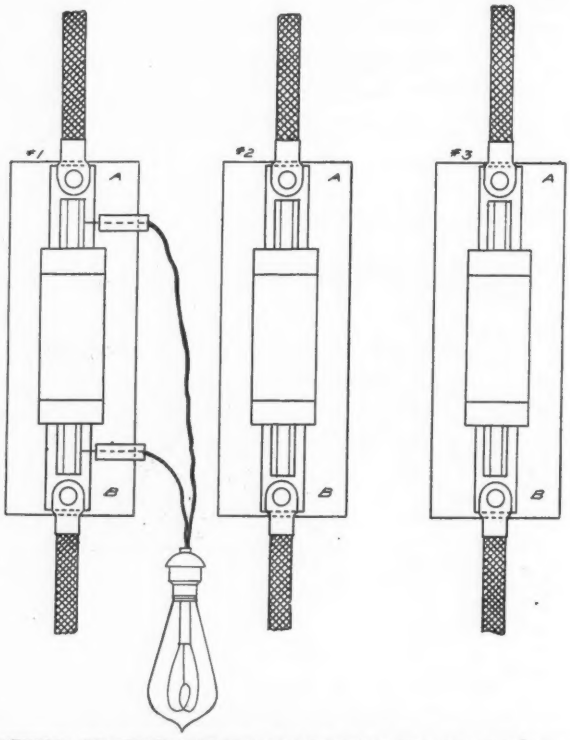
H. W. Rose.

I have been around a number of these wrecks and my version of a good number of them is that they are caused by the governor belt slipping. This is one part of a Corliss engine that is seriously neglected by so many engineers, because it lasts for years and gives little or no trouble. However, after a few months run they become oil soaked or get loose from stretching, and if this is not taken care of at once the engine may be wrecked at any time, and, of course, when an examination is made of the wreck everything, apparently, is in good working order; that is what is left. There are also a number of Corliss engine wrecks caused by the governor not being properly lubricated; this can be avoided by placing an oil cup on top of the governor staff. Drill a small hole down to the collar and regulate the cup to run about three to four drops a minute; this will lubricate the governor for the average engine running 10 to 24 hr.

R. Gordon.

Testing for Grounds and Short Circuits

In order to avoid bad flashes, due to electricians attempting to replace fuses in circuits closed due to motor starters being left in the running position, or short circuits on line due to grounds or breakdown of insulation between lines in conduit, or other causes, and also as a test on lines where the electrician is unfamiliar



METHOD OF TESTING THREE PHASE LINES FOR GROUNDS AND SHORT CIRCUITS

with the load connected to the lines, I would suggest the method of testing shown in the accompanying sketch.

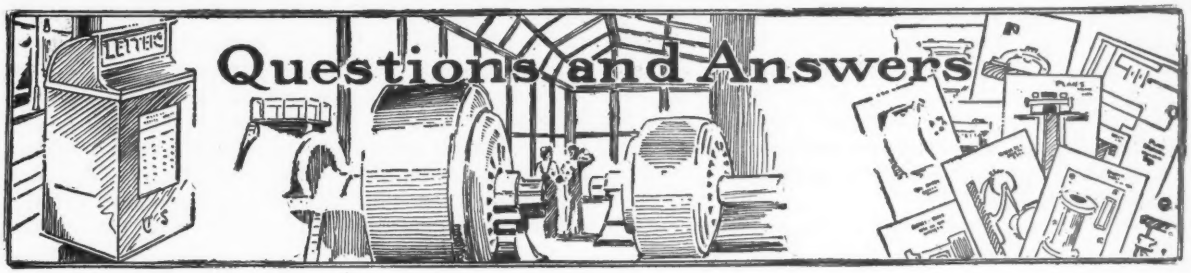
Before replacing fuse 1, test from A to B on the fuse block as shown by the test lamp; a dark lamp will indicate the line safe to replace the fuse while a lighted lamp will indicate a ground on the line and a ground on either phases 2 or 3 on the line side of the fuse block.

Before replacing fuses 2 and 3, make the same test on each as on fuse 1; a dark lamp will indicate the line safe to replace the fuse, a lighted lamp will indicate a ground, short circuit, or load on the line.

This test does not always show up a ground, as a single ground on the system or two grounds on the same phase will not be indicated.

J. H.

A new official world's record for airplane speed is reported to have been made at Villa Coublay, France, by a Spad single seater airplane equipped with 300-hp. motor, which accomplished 184 mi. an hour.



Electrical Heating Problem for Solution

I AM CONFRONTED with the problem of heating our main office electrically and having no practical experience with this heating system ask that some of the readers of Power Plant Engineering give some practical suggestions, omitting as far as possible technicalities.

We wish to maintain a temperature of 70 deg. F., average winter temperature outside being about 48 deg.; on coldest days, about 26 deg. early in the morning. Atmosphere generally damp and heavy. The building is of frame construction plastered inside, with a solid window space 30 ft. long, 12 ft. high, of steel frame on two sides, two standard doors and two standard windows on each side, four standard windows at one end and solid brick on the other end, and measures 74 ft. long, 32 ft. wide and 16 ft. high.

We operate our own plant here and have a surplus of about 100 kw.; fuel is no object.

Riding Cutoff at More Than Half Stroke

I NOTE J. M. F.'s inquiry on page 885, Oct. 1 issue as to whether an old style riding cutoff valve can be made to cut off at more than one-half stroke. This can be done in several ways, one of which is a combination of two eccentrics. Another way is to use a shaft guide on which rings are attached to the eccentrics, moving back and forth. A riveted pin on the flywheel under governor control may accomplish the desired result in some instances.

If J. M. F. had been more explicit as to the type of engine referred to, I could have given him more information. Answering his question directly, however, the riding cutoff valve can be adjusted to cutoff at more than one-half stroke. H. W. ROSE.

Stopping Water Hammer in Pipes

REFERRING to L. T. B.'s letter in the Oct. 1 issue, my advice is to put a larger air chamber on his discharge line. It can be made from pipe of a larger size than the discharge line and should be at least 2 ft. long. The top end, which should be the highest point in the pipe line, should be capped and an air cock fitting. When water hammer is heard, either in the pipe or the valves, opening the air cock will cause it to stop.

FR. A. LK.

AS THIS pipe disease is caused by various conditions, I will here mention the principal causes. Water hammer is the pressure of a wave of water coming in contact with some obstruction in the pipe line, which may be a closed end of a line, the entrance of the water into a smaller line, or half closed valve, etc. The pressure wave could be caused by the operation of a reciprocating pump driven by an engine and its source of supply from some main, or by the sudden closing, or partial closing of a valve or faucet. The pressure wave travels through the water at four times the velocity of air. It travels up stream at a terrific speed, meets the obstruction which reverses its direction causing it to collide with a following wave, thus producing water hammer.

Too many elbows may cause hammering, as may a badly corroded pipe to one-half its diameter. A steam valve in bad condition may cause uneven, jerky action of the pump causing the water to be delivered in the same manner. The water valves may need re-fitting or new springs; they may be so badly corroded as to diminish the amount of the water taken into the cylinder. The suction line may be corroded or too small for the pump, or the foot valve may be clogged up.

Any of these are possible causes of water hammer. Attention should be paid to proper lubricating oil for the cylinder, as well as the steam pressure used.

Should the check valve be on the same line, no further trouble will be experienced if the line is cured of the hammer, as the fault is in the line, not the valve. If the feed line is too small for its work putting in a larger valve may help some, otherwise a new pipe line should be installed. H. W. ROSE.

Keeping Pond Open in Winter

I NOTE J. H. E.'s communication in the Oct. 1 issue of Power Plant Engineering, and beg to state that his letter is lacking in detail as to what kind of a dredge he is operating (I presume it is what is known as a high land dredge), also as to what use this water is to be put to, and the approximate distance the water has to be conveyed from the ponds to the place of its usage, the amount of water that is required in circulation at all times, whether the dredge is operated night and day or only in the daytime, and the elevation of the ponds in connection with the dredge.

In regard to electrifying this water, I would not advise it, owing to the fact that it may be too costly. The problem as a whole is not only practical, but can be handled economically in a case of that kind, although not electrically.

I will look forward to future issues for further information along this line, as I am interested in problems of this nature. H. W. ROSE.

Determining Rated Capacity of Generator

WE HAVE a 2200-v., 98.5-amp., 60-cycle generator. What is its rated capacity? W. E. S.

A. You have failed to state whether the machinery which you mention is of the single, two or three phase type, and as a consequence we have determined the rating of each of the various types, so that you may be able to have the information desired.

The rating of a single-phase machine, expressed in watts, will be equal to 98.5 by 2200 or 216,700, which is equivalent to 216.7 kw.

For a 2-phase machine the rating would, of course, be twice this amount, or 443.4 kw.

In calculating the power delivered by any 3-phase, alternating-current generator, we employ the following formula:

$$P = \sqrt{3}\, E\, I\, p.f.$$

Where P is the power in watts:

$\sqrt{3}$ is equal to 1.73;

E is the voltage across any two lines;

I is the current flowing through any one line;

p.f. is the power factor expressed as a decimal.

You have failed to give the value of the power factor, therefore we are assuming it to be unity. We then have the following:

$P = 1.73 \times 2200 \times 98.5 \times 1$ or 374.981 watts, which is equivalent to 374.89 kw. A machine of this size would undoubtedly have a rated capacity of 375 kw.

An Ice-Making Plant Problem

I WOULD LIKE to get some information in regard to ice-making and refrigeration. We have an ice plant driven by electric motors, two compressors of 20 tons each, but we run only one at a time. We also have two tanks with 160 cans each of 300 lb. We pull 16 tons of ice in 24 hr. and refrigerate 12 tons at 28 deg. F. We kept the tanks about 15 deg. F. The water on the condenser is 60 deg. F. They are atmosphere condensers 30 ft. above the compressor.

We carry a head pressure about 135 and back pressure 15 lb. The plant runs fine. However, when I pump back to a vacuum the liquid stays out; but if I shut down for a half hour and start up, leaving the valve shut on the receiver, the liquid comes back. Why won't it come back when I first pump back? The condensers are working and do not seem gas or air bound; I purge them to run as often as they need it. C. L. H.

A. The first proposition to be considered is the amount of refrigeration actually required to maintain a temperature of 28 deg. F. in a storage room containing 12 tons of ice. In permanent ice storage houses, it is usual practice to allow from 50 to 60 cu. ft. space for each ton of ice. Where only 12 tons are held, however, we will assume that the ice is set on end and close together, as in an ice vault. It takes 80 blocks of 300 lb. each to make 12 tons. Each block will occupy nearly 2 sq. ft. of floor space. The room will then have 160 sq. ft. of floor space which will be covered by the ice. Then allow room for handling of the ice, and we have a room say 16 ft. long and 12 ft. wide, with a height of 8 ft.

The only factor we have to deal with will be the heat leakage through the walls, floor and ceiling. Altogether the surfaces will contain 832 sq. ft. With the ordinary insulation used in such rooms, the heat loss will be at least 2.5 B.t.u. per sq. ft. per degree temperature difference in 24 hr. Assuming an average outside temperature of 80 deg. gives a temperature difference of 52 deg. Then the entire heat loss will be $52 \times 2.5 \times 832$, or 108,160 B.t.u. To this must be added about 20 per cent for loss caused by lights, workmen and opened doors. Then the total heat to contend with equals 129,792 B.t.u.

As a ton of refrigeration is equal to 287,000 B.t.u., it means that not quite ½ ton of refrigerating capacity is required to take care of the 12 tons of ice in storage.

There is a big loss of capacity somewhere if a 20-ton ice-making capacity machine will produce only 16 tons of ice and care for a storage room of the size mentioned. As both ice tanks are used, we can consider them together as one tank, containing 320 cans. Allowing 14 cans to the ton, we have an ice-making capacity of about 23 tons, with a brine temperature of 16 deg. F.

Such tanks are usually provided with about 3600 ft. of ¼-in. pipe, or its equivalent in other size pipe. With good brine circulation, this amount of piping is sufficient to give a tonnage the same as the number of cans allows. With the ammonia compressor in good operating condition and with a full charge of ammonia, there is no reason why 20 tons of ice should not be pulled every 24 hr.

Twenty tons of ice will be equal to 133 blocks. Steady and regular pulling and filling is necessary to obtain full capacity, so this pulling should be at the rate of five blocks one hour and six the next. This will give 12 hr. of five blocks an hour and 12 hr. of 6 an hour. Divide the pulling equally between both tanks and keep both tanks at the same temperature. Pulling this amount of ice in the manner suggested gives sufficient time for the blocks to freeze solid when a temperature of 20 deg. is maintained.

See that the water enters the cans at the lowest temperature possible.

Now, instead of operating with 15 lb. of back pressure, the back pressure should be about 25 lb. At this higher pressure, the weight of each cubic foot of saturated ammonia vapor is 0.0919 lb., while at 15 lb. pressure the weight per cubic foot is 0.0368 lb. The capacity of an ammonia compressor is based entirely on the weight of ammonia handled.

Is the liquid ammonia received fitted with a gas return line from its highest point to the top of the ammonia condenser? There should be such a line, and if there is not it should be put in during the overhauling period. Drill and tap the top of the receiver and run a ½-in. line to the purge line of the condenser. While operating, leave the purge valve or at least one stand of the condenser open to allow the return of the light gas from the receiver.

As the compressors are motor driven, I take it for granted that they are constant speed.

Now, in pumping down with a steam-driven compressor, it is always best to slow the machine down as the pack pressure is lowered. The slow piston speed will allow the compressor to fill with the low-pressure light vapor. With high speed, the suction valves will not open till late.

With the usual speed of the motor-driven machine, the ammonia is not pumped out of the ice tank coils when the back pressure gage shows zero. (Never pump any part of an ammonia system quite down to atmospheric pressure unless it is absolutely necessary to do so. There is danger of pulling in air or moisture.)

With the constant-speed motor-driven machine, it is

advisable to pump down until the gage shows zero, then stop the machine for about 5 min. and start again. This may have to be repeated 3 or 4 times before the ammonia is really pumped out of the ice tank coils. The back pressure gage is, as a rule, connected to the suction line close to the machine. If another gage were connected to the low-pressure side of the system, between the expansion valves and the coils of the tank, it would be found to be very convenient where motor-driven machines are operated.

The fact that the liquid shows up when the machine is started after a half-hour stop shows that the tank coils were not pumped down as indicated by the back pressure gage. The liquid should always show in the glass on the receiver when the plant is operating normally. If it does not, the outlet from the receiver to the expansion valves is not sealed and noncondensed gas is passing to the evaporator, where it takes up room but does no work.

A. G. SOLOMON.

Fire Cracks

What are fire cracks, and how do they come to form?

A. R. H.

A. Fire cracks, more properly termed lap fractures, are particularly liable to occur in externally fired boilers, although they are quite frequently found in internally fired boilers, generally in the parts exposed to the fire. They are usually caused by using the drift pin too freely. The fractures may extend from the rivet hole to the edge of the plate, in which case they are not particularly dangerous, unless too numerous, and then the cracked part of the plate should be cut out and replaced by a patch.

Sometimes these cracks extend into the body of the plate and are apt to grow longer. They may be stopped by drilling a hole at the end of the crack and inserting a stop rivet at this point. Lap fractures are also apt to occur along the seam, and they may grow from one rivet hole to another, until they produce a seam rip. These are more dangerous than those extending to the edge of the plate, and should receive attention as soon as discovered.

A small number of lap fractures, each of comparatively short length, would not materially affect the strength of the boiler to such an extent as to warrant cutting down the pressure of the steam. If, however, there are a great number of such cracks, and each quite long, then, of course, boiler inspectors might consider it advisable to reduce the pressure.

Calculating Vacuum Pump Capacities

WILL YOU kindly give me a formula for calculating the size of a double-acting vacuum pump for use in connection with a 500 sq. ft. surface condenser? A vacuum of 26 in. is to be maintained.

A. M. J.

A. In order to give you a specific answer, it would be necessary to have considerably more data than that embodied in your letter, but for your information and assistance, we give you the following formula for calculating the theoretical capacities of vacuum pumps:

$$Q = v\, v_a \frac{P_a}{P_c - P_v} \times \frac{t^2 + 460}{t_a + 460}$$

Where Q is the total volume of air and water, in cubic feet per hour, to be handled by pump; v is the volume of condensed steam to be handled per hour; v_a is the volume of air at pressure Pa and temperature ta; Pa is atmospheric pressure, pounds per square inch; P_c is total pressure in the condenser, in pounds per square inch; Pv is the pressure of aqueous vapor at temperature t^2 which is the temperature of the discharge water, deg. F.; t_a is the temperature of the air entering the condenser, in deg. F.

This data may be quite readily secured, and by substituting the values of the various factors involved, you will be able to determine the size of pump required.

It should, however, be noted that the volume of air entering the condenser varies so much with the character of the power plant equipment and conditions of operation, that any assumed value of v_a may lead to serious error.

Cleaning Idle Boilers

CAN YOU tell us how, by the use of soda ash, we may clean the scale from an idle boiler?

How is the soda ash employed and for how long a period is it required to be used?

After any such treatment, is the boiler all right to use in the making of distilled water?

C. T.

A. The method of getting the scale out of a boiler not in use would be to put in a strong solution of soda ash; a ratio of about one pound of soda ash to 600 lb. of water.

The boiler should be filled clear full of this, the safety valve left open, and the water boiled for a period of 10 or 12 hr. at a brisk rate. The safety valve should then be closed, a pressure of 30 or 40 lb. gotten up on the boiler, and the water blown out under pressure.

The boiler should then be thoroughly washed by going into the manhole and soaking it out thoroughly with a stream of hot water, under considerable pressure, getting into all parts, so as to wash out the corners and crevices.

Inspection should then, of course, be made, and if any scale is found, the process would have to be repeated. It all depends on how heavily the scale is coated on, and how hard the scale is. Of course, some kinds of scale cannot be removed by this process, and will have to be gotten off by hammer and chisel. After this process is completed, the boiler can be used satisfactorily for distilling water.

Transformer Bank Capacities

WITH three 75-kv.a. transformers connected in delta for 440 and 220 v. on low-tension side, and two 60-hp. motors connected on 440-v. leads, what capacity is available on 220-v. leads?

W. L. F.

A. With the three 75-kv.a. transformers connected in delta, the total capacity on the transformers is three times 75, or 225 kv.a. The total capacity can be taken off from the 440-v. connection. If you have two 60-hp. motors connected on the 440-v. lines, this would leave approximately 100 kv.a. available from the 220-v. lines. We assume in all cases that the load is balanced between the three phases.

GENERAL ELECTRIC CO.
M. M. FOWLER.

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The Industrial Conference

Interest is at present centered in the work being done at the Industrial Conference which is meeting at Washington at the request of the President. Here are three groups of men representing the Public, Labor and Employers. Just what this conference will accomplish is difficult to say; judging, however, from reports received daily from the Council of National Defense, it is the object of the conference to draw up and pass a group of resolutions which shall represent a moral code for industry in its relations between employers, employes and the public. If such a code, acceptable to all representatives at the conference, is adopted, the next step is to provide some means for its enforcement or placing the violators in the class of the "persona non grata" in the industry of the country.

When it is realized that the conference is attempting something which is entirely new, that it was necessary to select the personnel of the committees, to adopt just rules of procedure, to weed out in committees all resolutions that have no chance of passing, then to bring all three factions together on as few resolutions as practicable which will bring about adjustments of differences between employers and employes—it is then we can appreciate what an enormous task is before the Industrial Conference.

In the daily press, during any controversy between employers and employes, the spokesmen for capital and labor would have us believe the other party is wholly to blame for not adjusting the conditions under discussion and that the differences are wellnigh irreconcilable. With this propaganda, for it is nothing else, in our minds, we are surprised at the similarity of the principles laid down by the three different groups at the conference, which each deems just and equitable, and upon which settlements of differences should be made. To study the principles offered by the two usually contending groups, is well worth the time of every citizen of the country. Not only will it clear up many false impressions which have crept into the minds of sympathizers with either side of industrial struggles, but it will give assurances that the industry of the country is on a firm foundation which will be difficult for any radical element to shake.

Expressed in as few words as possible, the principles of the labor group are stated as follows:

Organization.

Collective bargaining.

Representation by people of labor's own choosing.

Freedom of speech, press and assembly.

Collective bargaining by associations or groups.

Eight-hour day, and one day of rest each week; Saturday half-holiday should be encouraged and overtime discouraged but paid for at not less than time and a half.

A living wage.

Women—and consideration should be had for their sex—should receive the same pay as men for equal work.

Work of children less than 16 for private gain prohibited.

Systematic review of industrial conditions by those directly concerned in each industry—a national conference board in each industry, encouraged by the depart-

ment of labor, and all when required meeting jointly. Qualify the department of labor to advise such boards on matters affecting the welfare of the wage earners.

Prohibition of immigration for at least two years after peace shall have been declared, and regulation of its flow with view to Americanization and unemployment, prohibiting it entirely when employment conditions are abnormal.

Contrast with the above, if you can, the principles formulated by the employers' group, which are briefly stated below:

No artificial restriction upon product or labor.

The establishment rather than the industry to be the unit of production and of mutual interests.

Conditions of work to be "as safe and satisfactory to the workers as the nature of the business reasonably permits."

Wages to maintain a man and his family "at a standard of living that should be satisfactory to a right-minded man in view of the prevailing cost of living."

Women doing work equal to that of men should be paid the same.

The standard of the work schedule should be the week, with variations, avoidance of overtime when possible, and with one day of rest when possible.

Each establishment should provide for settlement of disputes, "but there should be no improper limitation or impairment of the exercise by management of its essential function of judgment and direction."

Collective action by employers, employes or others involves no right of compulsion over those who do not desire to act with them as an association.

Every association, or its agents, is subject to public authority.

Every person must be free to enter into any lawful contract as employer or employed, and be secure in the continuity and rewards of his effort.

There should be no interference with the "open shop," and no employer should be required to deal with men or groups of men who are not his employes or chosen by and from among them.

However much the strike or lockout in private industry is to be deplored, the right should not be denied as an ultimate resort—but the "sympathetic strike is indefensible, anti-social and immoral. The same may be said of the blacklist, the boycott and also of the sympathetic lockout." In public utility service the state should assure continuous operation, and a strike of government employes cannot be tolerated.

Our educational system should be adjusted to the needs of industry.

Most of these principles set forth will be considered just by all fair-minded people familiar with industrial conditions; other questions are, however, meeting with considerable discussion and opposition in the conference. Among these is the question of collective bargaining, the right of which is not denied by employers, but the methods sometimes employed are questionable and naturally are being opposed.

Another resolution which will be subjected to considerable debate is that dealing with the open shop, the closed union shop and the closed non-union shop. The work of the conference has progressed far enough, however, to predict that the country at large will be enlightened on the many sides of controversies between employers and employes, and with this knowledge of the principles of contending groups public opinion will have great weight in compelling rapid adjustment of differences. When this conference is over, the problems of collective bargaining; unemployment and unemployment insurance; mediation, conciliation and arbitration; cost of living; hours of labor; wages; women and children in industry; immigration; production; industrial training and many more questions in human engineering will have been discussed in public by men on both sides of debatable questions.

The conference, however, is only the beginning of the good to be derived by the discussions which take place. It is for the engineer to put the principles into practical use. His positions in many cases as "buffer" between capital and labor puts this responsibility upon him, and he welcomes such public discussions, as they not only give him ideas to work upon but prepare those with whom he must deal for such suggestions and recommendations as he may make.

Canada's Niagara Project

A vast amount of power is still going to waste at Niagara, but the problems encountered in putting this power to use are not so easily solved as are the usual hydroelectric developments. Being on the border between Canada and the United States, every plan presented becomes an international political question. So much sentiment has grown up about these Falls that the public in both countries seem to prefer that the Falls be left in their natural state rather than to take economic advantage of the power going to waste there. While the engineering problems presented are gigantic, they are not impossible nor even experimental, but naturally they are features of special interest.

With the principal legal and international problems solved, the Hydro-Eectric Power Commission of Ontario is rapidly proceeding with the excavation and construction project practically without the use of steam. This is the largest engineering feat ever attempted in Canada and the biggest engineering job now under way in North America.

The original survey for this development was made in 1914 and construction work was begun in May, 1917, but it is not likely that the power plant will be in working order before 1922. Naturally, war conditions delayed the work greatly; but this year great progress has been made. It is estimated that the cost of the entire project will be approximately $27,000,000. In the construction work, 55 mi. of electrified railway, tapping five trunk lines, are used and at present 2000 men are employed on the job.

Although construction work is not much more than started on the power plant, as will be noted in the leading article of this issue, we can gain from this description something of its magnitude in the influence it will have upon the industrial development of the Province of Ontario, throughout which high voltage lines will distribute the power developed.

Power Plant Records and Analysis Number

The Moving Finger writes; and having writ,
Moves on: nor all thy Piety nor Wit
Shall lure it back to cancel half a Line,
Nor all thy Tears wash out a Word of it.

THE Moving Finger of Science is writing in every branch of human activity—in every nation and in every business—as never before. It will trace in indelible characters the names of thousands of new industries, and old industries made new, which are founded on the new standards of scientific knowledge which can alone bring enduring economy.

It points to the economies in the model plants, familiar to readers of Power Plant Engineering, which have been erected during the present era of high prices and scarcity of fuel, labor and materials.

In old plants engineers are studying how to make alterations in methods and equipment that will enable their plants to compete with these model plants. At the same time they are studying the equipment they shall select for the new additions and new plants which they know, better than any other group of business executives can know, must be scientifically built to supply the overwhelming demands of an awakened industry.

Nowhere in commerce does the moving finger write more quickly or exactly the tale of profits or losses than in power plants. Coal, oil, supplies and labor can make or break a business today with a speed never before attained.

Here the moving fingers of many instruments write of how fuel is being burned, how heat units, steam and electricity are being utilized, and how men are attending to their duties. And the final analysis of these records is the reprieve or death sentence of grates, stokers, boilers, engines, valves, piping, unions and other equipment, even to the oil which lubricates a bearing and the packing which guards pressure or vacuum.

Power Plant Records and Analysis

HELPFUL records have been the most neglected of any feature of power plant management. Yet there is no work in a plant which will yield greater returns for the effort expended than keeping and studying, systematically, records of operation and costs.

Unfortunately, this fact has been appreciated only in the largest and most modern plants, although the benefits from such records and their study are even greater in the moderate sized plant and that in which the equipment is less complete and efficient.

In the Power Plant Records and Analysis Number of Power Plant Engineering, January 1, 1920, it will be the object to point out the data needed, to show how it may be obtained and how to use it effectively in all sizes of plants.

Why Keep Records?

UNDER this heading will be discussed four general uses of records: To determine unit costs; to determine efficiencies; to reduce unit costs; and to indicate needed improvement.

Unit Costs

THESE are made up of cost fuel, water, oil, waste, supplies, labor, repairs, new equipment, fixed charges and overhead.

Each of these items will be explained in detail and its relative effect upon unit costs pointed out. Several big sheets which have been used successfully in power plants of different characteristics will be presented.

Efficiency

THE efficiencies of various units in the power plant play such an important part in the operation that considerable space will be used in presenting forms needed for getting data from which the efficiencies of the principal equipment can be determined.

Needed Improvements

PARTICULARLY timely is this section of the general subject. Many plants are somewhat run down as a result of intensive war work, and should have considerable overhauling and additions. Under this head will be indicated the data needed for making a reasonable decision as to when machinery should be replaced or new machinery added; when equipment has reached its limit of usefulness either by wear or by becoming obsolete.

Analyzing Records

RECORDS are practically useless unless they are studied to see what they show, and the management of the plant is guided by the information so obtained. Ability to interpret the records of conditions and operation of a plant proves that an engineer is master of his calling.

In this section will be given, therefore, logical methods for determining quickly and easily the effects of changing conditions in a power plant, and the effects of such changes on costs.

Efficiency Tests

USES to which data from such tests may be put will be explained in detail. Every piece of apparatus in the plant has its function to perform. How well it is performing is shown by the efficiency test. Each piece works best under some certain set of conditions and the planning of operation so as to take advantage of this point of highest efficiency is a complicated problem, the solution of which will be explained.

Daily Records

HOW to study them; what effect conditions outside the control of the engineer may have; and a system of analysis which, if carefully followed up, is bound to produce good results will be fully explained. In this analysis, numerous curves, charts and tables, fully cross indexed, will be given.

What Changes?

TO DETERMINE what improvements are needed, a careful study of rated capacities, operating efficiencies, load curves, load factors, cost of repairs, number and length of shut downs, must be made. How to do this from the data in the records will be fully illustrated. Throughout the issue, the object will be to give methods which are applicable in every plant.

Instruments and Measurements

THE CHIEF data needed will be concerned with weights, pressures, temperatures and energy. Fuel and water are the primary raw materials of the power plant from which are manufactured power, light, heat and refrigeration. It is necessary to determine, therefore, the weights of raw materials used.

The principles of construction, installation, operation and care of measuring devices such as scales, hoppers, meters and tanks will be explained and the application to measuring weights of fuel, water, steam and condensation.

Pressures

SAFETY of operation, as well as determination of efficiencies requires a knowledge of pressures in boiler, condenser, tanks, pipes and compressors.

Various types of instruments, indicating and recording gages are used, and the mechanism, proper choice and accuracy of reading of each type will be fully considered.

Temperatures

TO JUDGE the effectiveness of heaters, refrigerating apparatus, furnaces, and condensers, we must know the temperature at which they are operating. For getting these, thermometers and pyrometers are the means; their type, uses, ranges required and proper methods of use will be explained in detail.

Energy Measurements

CONVERSION of energy from one form to another, and utilization for performing different kinds of work is the field of the power plant engineer. Of utmost importance to him is the effectiveness of his conversions and the efficiency with which he uses the energy.

Instruments needed for such determinations include indicators, dynamometers, brakes, electrical meters, as well as the weight, pressure and temperature measurements. The why and how of the various devices, what are essential for each test, what readings are indispensable, and what are auxiliary; how to secure data most easily, and alternative methods when some instruments are lacking will be fully treated.

The gas analysis is one of the best methods of getting a line on what is taking place in the furnace. In the boiler room lies, perhaps, the greatest opportunity for loss from lack of exact knowledge of what is happening. Hence, careful attention will be given to the subject of fuel and fuel gas analysis.

In the Power Plant Records and Analysis Number will be comprised the best and latest information and methods to enable the engineer to manage and operate his plant so as to get the best results in economy and the lowest costs in power production.

Synchronous Motors for Refrigerating Compressor Operation

DURING recent years, a change has been made in the method of driving refrigerating machines by motors. Formerly, almost all motor-driven compressors operated at speeds of around 70 r.p.m. and were driven by belted induction motors. Today, the preferred type is a compressor of from 150 to 250 r.p.m., with a synchronous motor mounted directly on the shaft. This modern practice is well illustrated by an installation recently put into operation in a Brooklyn ice plant and shown in Fig. 1, and which consists of six 15 by 15-in. compressors driven in sets of two by three 350-hp. direct-connected synchronous motors.

As far as the change in drive of the compressor is concerned, this is chiefly due to the fact that the slow-speed compressor is, for reasons well known to refrigerating men, being displaced by the high speed machine. About the only way to drive a machine of 70 r.p.m. by a motor is to use a belt, because, though a 70-r.p.m. motor for direct connection could be built, it would be very large and expensive. But, as soon as the speed of refrigerating machines rose above 175 r.p.m., then direct connection became entirely practical and is being generally employed because of the following advantages:

A compressor with a direct-connected motor forms a much simpler and more compact outfit than a compressor with a belted motor.

The belt is eliminated, which does away with the cost and trouble of belt maintenance.

The motor, being mounted on the compressor shaft, needs no base, pulley, bearings, or shaft of its own.

The rotor of the motor acts as a flywheel so that the flywheel of the compressor can be lighter and less expensive.

There is a slight gain in the efficiency of operation, since losses due to belt friction are eliminated.

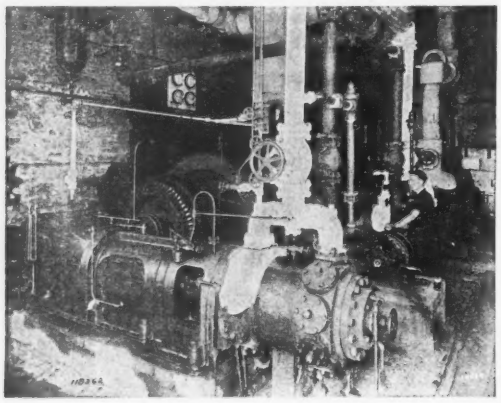


FIG. 1. TWO 15 BY 15-IN. COMPRESSORS DRIVEN BY A 350-HP. SYNCHRONOUS MOTOR

Synchronous and Induction Motors Compared

THE REASONS for the use of the synchronous motor in place of the induction motor are not, however, so self-evident.

The synchronous motor is an alternating-current generator, with a few structural changes, used as a motor.

It is somewhat more complicated in construction than the induction motor; it needs a small direct-current generator, an exciter, to energize its field coils; it cannot start a load that is much greater than ⅓ of its rated full loads; and it is strictly a single speed machine.

The induction motor, on the other hand, is the simplest and cheapest type of motor made; it needs no exciter; it can start loads two or three times larger than its rated full load, and can be arranged for speed control or supplied in a two-speed type, which is frequently used for refrigerating purposes.

It would seem from a consideration of these characteristics that the induction motor should provide the more satisfactory drive, and, indeed, it was this view that has been responsible for the extensive use of induction motors for compressor drive in the past. But the synchronous motor has one important advantage over the induction motor which makes its use desirable wherever possible; this advantage is that it can keep the power factor of the circuit on which it operates at 100 per cent.

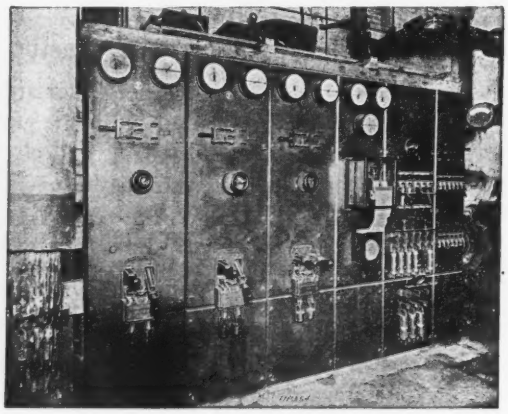


FIG. 2. SWITCHBOARD FOR CONTROL OF SYNCHRONOUS MOTORS DRIVING COMPRESSOR UNITS

It is difficult to discuss the subject of power factor in a few words; but, briefly, low power factor means a loss of power. When the power factor of a circuit is 80 per cent, only about 80 per cent of the current flowing through it is available for producing power; the remainder circulates idly, requiring coal to produce it and copper to carry it, but unable to do useful work. Hence with an 80 per cent power factor, the generator, transmission lines, transformers, and other apparatus must be 25 per cent larger than would be necessary to handle the same amount of power at a power factor of 100 per cent. Other disadvantages, such as poorer voltage regulation, are also caused by low power factor. Under the best of circumstances, the power factor of an induction motor is not much over 90 per cent; while, for very low speed machines, such as would be necessary for direct connection to refrigerating compressors, the power factor is even lower. The synchronous motor, however, not only operates at 100 per cent power factor itself, but also can be arranged so as to connect the lowering of the power factor by induction motors operating on the same circuit.

The use of the synchronous motor by an industrial plant is therefore advantageous because it provides current of the most desirable characteristics and permits the use of smaller transformers and other apparatus. To the central station the maintenance of high power factor on its lines is of great importance, because the idle currents that appear with low power factor are a source of expense but create no revenue; hence, central stations encourage the use of synchronous motors wherever they can be properly used.

On account of its limitations of more complex construction, higher first cost, low starting torque, and unchangeable speed, the synchronous motor cannot be used for a large variety of application; but compressor drive is work that is well suited to it. Starting under full load is avoided by bypassing the compressor until full speed is attained and then throwing on the load. Reduced capacity in cold weather is obtained by driving two compressors by each motor, as in the installation illustrated, and using both in summer and only one in winter, instead of reducing the speed of the outfit. The more complicated construction of the synchronous motor is not an actual drawback, since the modern synchronous motor is quite as reliable, as easily operated and as readily repaired as the induction motor. Though its first cost is somewhat higher than that of an induction motor of the same capacity, the synchronous motor is somewhat more efficient and will save the difference in price in a short time by lowering the power bills.

Hence the synchronous motor is in every respect as satisfactory as the induction motor for driving refrigerating compressors, while its ability to maintain a 100 per cent power factor makes it superior. So generally has this fact become recognized that, as a matter of fact,

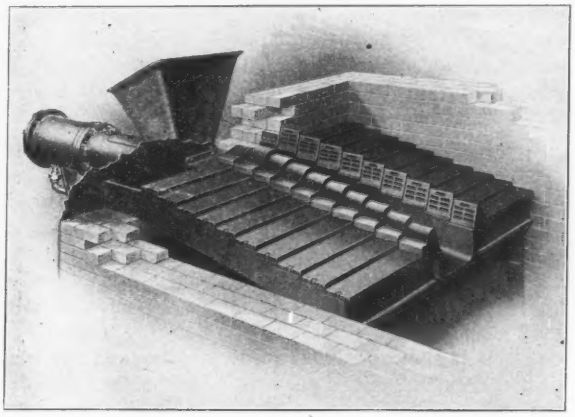


FIG. 1. GENERAL VIEW OF STOKER

electrical manufacturers do not supply induction motors in the proper sizes and speeds for direct connection to refrigerating machines, but offer synchronous motors only.

The Switchboard

THE SWITCHBOARD for controlling the equipment shown in Fig. 1 is illustrated in Fig. 2. Each of the three left-hand panels controls a single motor-driven unit and carries the following equipment: A power-factor meter and an ammeter, a motor field-switch, a motor-field rheostat and at the bottom a starting switch for the motor which is so arranged that the motor cannot be started improperly and which provides protection from loss of voltage and overloads.

The fourth panel carries the following instruments for the main circuit: Power factor meter, ammeter, voltmeter, graphic wattmeter and integrating wattmeter. The two right-hand panels control the lights and the small motors throughout the plant.

A New Underfeed Stoker

THERE ARE a number of interesting features in the design of the latest addition to the list of underfeed stoker. The principle of this type of stoker is so well known that reference to Fig. 2 is all that is necessary to understand the operation of this particular stoker.

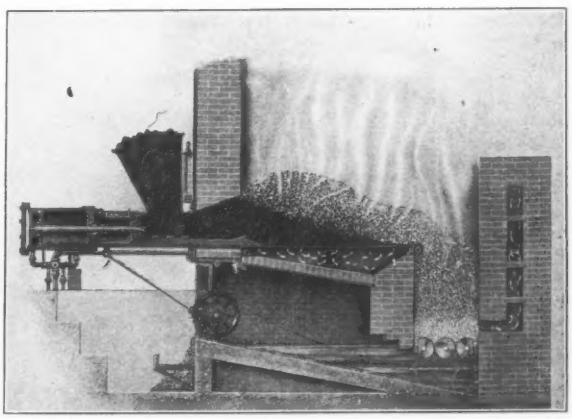


FIG. 2. CROSS SECTION SHOWING COMBUSTION CHAMBER AND ASH HANDLING ARRANGEMENTS

The unusual features, however, are the supplemental combustion chamber, and the method of ash removal. The supplemental combustion chamber is located in back of and below the retort. Any coal which has not been completely burned in the main fuel bed will, on passing into the supplementary combustion chamber, be supplied with additional air through ducts in the bridge wall, so as to secure practically complete combustion.

At the lower end of this chamber, which is water sealed, are located tubular or disc ash supports. In small plants, these supports are operated manually, by means of hand levers, but in the larger plants they are operated automatically by the stoker ram. One method of accomplishing this is shown in Fig. 2, where the ashes are removed by means of endless chains running over sprocket wheels, which are in turn actuated by the crosshead through a ratchet wheel. To these chains are fastened a number of scrapers which gather the ashes from the ashpit and deliver them at the front of the boiler, where they may be disposed of by means of an ash conveyor, or by hand.

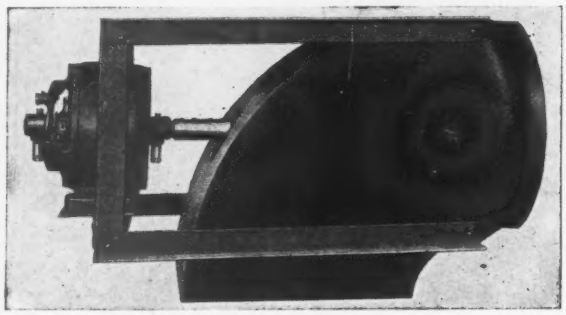
The back sprocket wheel shaft carries, besides the sprockets, a gear to work the ash supports above. Thus the ashes are removed at the same rate that they emerge from the combustion chamber.

Clinkers are the result of the fusion of various refractory substances, the formation of which can be largely prevented in this stoker, it is claimed, by the

movement of the breaker bar which tends to prevent stratification of the fuel bed, and by the introduction into the fuel bed of the elements of water, hydrogen and oxygen. Water in the water seal ascends the body of ashes by capillary attraction to a point where the heat is sufficient to cause disintegration of the water, which passes into the fire in the form of gases. The water carried by the pipe seen immediately under the back edge of the main combustion chamber, while primarily for cooling purposes, is also reduced to its elements.

A New Small Capacity Exhaust Fan

THE open type of exhaust fan which consists ordinarily of a fan mounted in a suitable frame or holder, placed in an opening in the wall or window of the room to be ventilated, proves satisfactory when the air to be handled is reasonably free from solid matter. When, however, as in the case of laboratories,



THE NEW SCRUPLEX EXHAUSTER

kitchens, etc., the air carries grease, steam, and fumes or other vapor, likely to injure the motor or make it difficult to clean, it is advisable to protect the working parts by removing them from the path of the air.

In the Scruplex Exhauster, this is accomplished by providing an air duct of a shape similar to the ordinary large steel encased blower fans. The motor is placed on a bracket back of and fastened to the duct, the shaft running through the wall of the duct, to the fan placed in the outlet. The shaft, as well as the fan bearing, are encased in a tube, effectually protecting them from the harmful action of any matter which the air may contain. Aside from the cleanliness assured by placing the motor outside the duct, it also reduces the liability to neglect on account of inaccessibility.

This fan is made with either one or two inlets, which may be located in various positions; and in capacities from 900 to 11,500 cu. ft. per minute.

IT IS reported that the city of Vienna, on Oct. 2, decided to purchase 30,000 tons of American coal for use in municipal electric lighting works. Owing to high foreign rate and depreciation of Austrian money, purchase price is estimated at about $40,000,000, or $500 a ton, which amounts to six times the price for Silesian coal.

BUREAU OF NAVIGATION reports 200 sailing, steam, gas and unrigged vessels of 374,165 gross tons built in the United States and officially numbered during September, 1919.

Steel Clad Transformers

ANNOUNCEMENT is made of an improved line of distribution transformers, the chief advantage claimed being a reduction in weight of over ⅓ by the substitution of a welded sheet-steel case for one of cast-iron. It is claimed that a construction has been achieved which combines the light weight desired with the requisite degree of strength and rigidity and, furthermore, includes a treatment and finish of the tank surface which renders it thoroughly weather proof.

The ease and cheapness with which distribution transformers can be shipped, handled and installed, is to a large degree a question of weight. Further, since distribution transformers are usually mounted on poles. heavy transformers are particularly objectionable, not only because of the difficulty involved in raising them into position for hanger iron mounting, but also because of the strain put upon the pole and cross-arms. The distance from the center of gravity of the transformer to the center of the pole is a matter of almost as much importance from the point of strain on the pole and cross-arms as the weight itself.

Reduction in weight effected in the steel-clad transformers permits of mounting larger transformers directly on poles without building a platform. The new 10, 15 and 50-kv.a. transformers are about the same weight as the old 5, 7½ and 25-kv.a. transformers. respectively, which shows that between these limits of capacity with the same strength of support the transformer capacity can be doubled with the new transformers.

The material selected for the manufacture of the tanks, covers, and end frames is a special grade of sheet-steel particularly adapted to the conditions of manufacture and service. It can be readily drawn, and in addition it has inherent rust-resisting qualities. This, combined with an extremely good finish, it is claimed, has resulted in the production of a tank which is permanently weather-proof.

Weather-proofing of the transformer cases consists of the following operation: (1) sandblasting to remove the scale and dirt and to roughen the surface; (2) applying and baking on a coat of priming paint; (3) applying and baking on a finishing paint. The priming coat is a special grade of paint which it is claimed when applied to clean metal, forms one of the most effective coatings known for its preservation. The finishing coat is heavy oil and is designed to withstand the wear of the elements. Its function is to protect the first coat, which is adjacent to the metal and which gives the real protection to the tank surface.

The color of the finishing coat is a battleship gray. giving a smooth attractive finish, from the standpoint of civic pride.

A complete steel-clad transformer case is made from five different parts. The rim and base of the tank are drawn out from a single piece of sheet-steel. The tank wall is formed from two sides which are drawn and welded and the rim and base are welded to the tank wall. Thus, four parts complete the tank and one part the cover.

LEISURE and Laziness—next door neighbors.

Express Packing Rules

NEW express packing rules, similar to those required for freight movement on the railroads, will go into effect Dec. 10, and express shippers are requested to prepare themselves for the new standards. The new packing requirements, which were recently approved by the United States Railroad Administration, were formulated to provide additional safeguards for merchandise sent by express.

Preparations are being made at local offices of the American Railway Express Company to put the new rules into effect on Dec. 10, and to require a strict adherence to them thereafter. The express officials expect that in this way shippers will be induced to pay greater attention to their packing methods and to turn their business over to the carrier substantially packed and clearly marked, so that, with reasonable care on the part of expressmen, all traffic can be handled rapidly and with fewer chances of loss or damage in transit.

The rules, recently promulgated, will not permit the use of paper wrapping for packages over 25 lb., nor ordinary paper boxes, wrapped or unwrapped, when the weight of the package is over that limit. For shipments over 25 lb., wooden containers, or containers of fibreboard, pulpboard or corrugated strawboard material are required. The cartons must be made of materials of specified "test strengths," similar to those required for the freight service, and the containers must bear the stamp of the manufacturers certifying that the material used is of strength required for the weight of the shipment carried in it, as called for in the rules.

The express regulations, though modeled on those for freight movement, permit a wider latitude in the size of the carton used, and carry a certain number of exceptions. Shippers who wish to acquaint themselves with the new express regulations are requested to study Supplement No. 5 to Express Classification No. 26, in which these rules are embodied, and copies of which may be secured at any express office. It is calculated that the time remaining before Dec. 10 will be sufficient to enable express shippers to adjust themselves to the new packing standards.

News Notes

THE EIGHTH ANNUAL MEETING of the National Drainage Congress will be held at the Planters Hotel, St. Louis, Mo., Nov. 11, 12 and 13, 1919. John A. Fox, formerly Secretary of the Mississippi River Levee Association and now connected with the Wisner Estates, Inc., will act as Director of the Drainage Congress until this meeting is held.

At this meeting the National Drainage Congress expects to determine its attitude towards the Mondell Bill and the Smith-Chamberlain Bill. The Mondell Bill appropriates $500,000,000 for the purchase of land to be resold to the soldiers, sailors and others of our military forces in the late war. The Smith-Chamberlain Bill authorizes government financing of any irrigation, drainage or cut-over project which may receive the approval of the Secretary of the Interior.

A number of interesting addresses and discussions will be had and a large attendance is confidently expected.

THE SOCIETY FOR ELECTRICAL DEVELOPMENT has announced a campaign to make this an All-Electrical Christmas. Representatives of the Society have just completed a survey covering 16 states and the Province of Ontario, Canada, during which electrical conditions in every branch of the industry were studied at close range. In most cities, the contractors, dealers, jobbers and manufacturers reported the greatest volume in their history. Manufacturers and distributors of electrical specialties, particularly, are far behind on orders; dealers in these devices are finding ready sale.

W. L. SAUNDERS, Chairman of the Board, Ingersoll-Rand Co., of New York, was elected President of the American Manufacturers' Export Association. The election took place at the Business Session of the Tenth Annual Convention of the Export Association which opened Oct. 16 at the Waldorf Astoria Hotel. Mr. Saunders, who is well known in foreign trade circles throughout the country succeeds George Ed. Smith, President of the Royal Typewriter Co., who has served for the past 2 yr. as President of the Export Association.

IN CONNECTION with the insistent demand for malleable castings, the American Malleable Castings Association reports that this condition has been anticipated and that ample facilities have been provided for both the present and future expansion for the industry, but that at the present time the shortage of unskilled labor will not permit this great capacity being used. Fully 200,000 tons of malleable capacity is today idle, which would be immediately available if the necessary labor could be secured.

Improvement in this direction is not looked forward to with any great hope until the activities of other industries are curtailed or until there is a flow of immigration sufficient to build up the supply of labor available for foundry work.

WILLIAM E. RICHARDS announces that he has admitted to partnership Oscar A. Geier, the firm name becoming Richards & Geier. This act is in recognition of Mr. Geier's faithful and efficient co-operation in the past which has, in a large measure, contributed to a healthy expansion of the business. The location of the firm's offices will remain unchanged at 277 Broadway, New York.

THE CANADIAN GENERAL ELECTRIC CO., with headquarters in Toronto, has become a Member of The Society for Electrical Development, as have several other Toronto Contractors and Dealers. It is planned to extend the work of the Society throughout the Dominion on an increased scale. Frederick Nicholls, who for over 30 yr. has been prominent in Canadian electrical industrial activities, is President and General Manager of the Canadian General Electric Co. A. S. Edgar, Supply Sales Manager, together with Mr. Horton and Mr. Mallett, from the main office, have been spending considerable time in the offices of the Society planning the co-operative work.

The company is building a new structure to house what will be the finest and most complete electrical show rooms in the Dominion. Many unique features will be incorporated in this department, which will be

operated largely for the convenience of the contractors and dealers of Toronto and the surrounding cities. There will be rest rooms, consultation rooms, with stenographers in attendance, rooms for demonstrations of electrical appliances and specialties and provision made for carrying on a vast educational work within the trade.

THE INDUSTRIAL GROWTH of Texas and Oklahoma, the ever increasing importance of their oil industries and the large demand made for modern machinery in this and other lines, has led the Ingersoll-Rand Co. to establish a branch office to serve better the rapidly developing industries of this territory. The new office located in the Sam Houston Life Building, Dallas, Texas, will be in the charge of R. H. Brown, Jr., as manager. Mr. Brown has heretofore been connected with the company's St. Louis office and has, for years, been in intimate touch with the Texas-Oklahoma territory.

H. W. PHILBROOK, formerly with the General Electric Co. of Schenectady, has been appointed District Manager of the Schutte & Koerting Co.'s New York Office, 50 Church St.

THE CHICAGO PNEUMATIC TOOL CO. announces the appointment of Fred Gehbauer, as Special Navy Yard Representative, with headquarters at their Philadelphia office, 1740 Market St.

U. S. CIVIL SERVICE EXAMINATIONS have been announced to take place on Nov. 11, as follows: Junior Mechanical Engineer, salaries $1800 to $2000; Electrical Engineer, $2400 to $3600; Assistant Electrical Engineer, $2000 to $2400; Electrical Assistant, $1500 to $2000. Apply for Form 1312 for Junior Mechanical Engineer or Electrical Assistant, or Form 2118 for Electrical Engineer or Assistant Electrical Engineer.

UNITED STATES CIVIL SERVICE COMMISSION announces an examination Nov. 18, for research operator—metallurgical. Vacancies under the Ordnance Department of the War Department, for duty at ordnance plants, arsenals, or in Washington, D. C., and in positions requiring similar qualifications, will be filled from this examination. The register of eligibles will be divided into two grades, as follows: Grade I, $1500 to $2000; Grade II, $2000 to $2500. After 6 mo. satisfactory service in Grade II appointees will be eligible for promotion to Grade III, in which the salaries range from $2500 to $3000. Competitors will be rated on education and general experience, and research metallurgical experience. Applicants must have reached their twenty-first birthday on the date of the examination. Age limits do not apply to persons entitled to preference because of military or naval service. Apply for Form 1312.

STEAM TURBINE BLADING is the title of Bulletin No. 1104 recently received from Allis-Chalmers Mfg. Co. This is an interesting treatise on a subject with which power plant engineers should be familiar.

TESTS to determine the resistance of passenger trains at all speeds up to seventy miles per hour, and for average car weights have been completed by the Railway Department of the Engineering Experiment Station of the University of Illinois. From the results a table has been prepared showing the probable average value of resistance for passenger trains composed of cars weighing from 30 to 70 tons and operating at speeds ranging from 5 to 75 mi. per hour. Copies of Bulletin No. 110 may be had without charge by addressing the Engineering Experiment Station, Urbana, Ill.

COAL IS the title of a booklet which has just been issued by the Under-Feed Stoker Co. of America. This volume gives complete information covering proximate and ultimate analyses of coals from every mining section in the United States, as well as some other valuable information on coal and coal consumption.

STATEMENT OF THE OWNERSHIP, MANAGEMENT CIRCULATION, ETC.

required by the Act of Congress of Aug. 24, 1912, of Power Plant Engineering, published Semi-Monthly at Chicago, Ill., for October 1, 1919.

State of Illinois
County of Cook
ss.

Before me, a Notary in and for the State, DuPage and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse side of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business managers are:

Name of— Post Office Address—
Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, None.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
A. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association or corporation has any interest, direct or indirect in the said stocks, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is.....

(This information is required from daily publications only.)

Charles Sanford Clarke, Secretary.

Sworn to and subscribed before me this 27th day of September, 1919. Warren A. Lathrop, Notary Public.

(SEAL) (My commission expires Oct. 16, 1922.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the post office. The publisher must publish a copy of this statement in the second issue printed next after its filing.